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A COMPARATIVE SENSORY ANALYSIS OF HELEN KELLER AND LAURA BRIDGMAN

I. MECHANISMS UNDERLYING THE SENSORIUM *

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NEW YORK

Several years ago, in an address to the American Neurological Association, I ventured the statement that the human race had not as yet developed more than a fifth of its potential brain power. With other evidence in support of this view, I [1] offered certain deductions based on the history and achievements of Helen Keller. Since that time, I have had the opportunity and privilege to study Miss Keller personally. It is now my purpose to assemble the results of this study in their fuller bearing on the potential development of the human brain and also to present a comparative sensory analysis of Helen Keller and Laura Bridgman. Such an analysis in itself must needs be a contribution to that partially written chapter in the annals of the sensorium which records the adaptive successes of the deaf and dumb and blind.

HEAD'S THEORY OF SENSIBILITY

Before I discuss Miss Keller's sensory organization, it seems desirable to consider certain theoretical postulates concerning the mechanisms underlying the sensorium as a whole.

The most convenient point of departure for such a consideration appears to be the theory of Henry Head and his collaborators, founded on their intensive studies of change in skin sensibility following division and suture of the cutaneous nerves. In consequence of this procedure, Head formulated the theory that there are two chief sense qualities in cutaneous sensibility; one component of this duality he called "protopathic" and the other "epicritic." This theory has been extensively discussed and has exerted widespread influence on all modern conceptions of sensation. In late years, no work in this field has appeared

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* From the Department of Neurology, Columbia University.

* Read at the Fifty-Fourth Annual Meeting of the American Neurological Association, Washington, D. C., May 1, 1928.

1. The writer wishes to apologize for the frequent intrusion of the personal pronoun. On the other hand, this form of narration was purposely chosen for the reason that subject matter of this kind is readily converted into objectionable dogmatism if presented in more indirect discourse.

without giving conspicuous prominence to the theory of Head. It was necessary, therefore, for me to consider its general availability and pertinence in the studies undertaken to determine Miss Keller's sensory capacities. The theory accepted as intended by its author presents a broad generalization concerning the nature of sensation. It aims primarily to afford an evolutionary interpretation. Its principal conception is the distinction of two great sensory systems, classified as follows:

1. The "epicritic" system, which provides: for the recognition of light touch over hairless portions of the skin, or parts that have been freed of hairs; discrimination of intermediate degrees of temperature from about 25 to about 40 C.; localization of cutaneous impressions; discrimination of two compass points as two points; appreciation of differences in the size of the stimuli and mediation of all sensations by a mechanism which for the heat senses is not distributed in a punctiform manner, and which for pressure, although punctiform in that the most sensitive spots lie over the hair bulbs, is yet of a different kind from the punctiform organs for protopathic warmth, cold and pain.

2. The "protopathic" system, which provides: for sensation of cutaneous pain by pricking, burning, freezing, electric stimulation or plucking the hairs; the hair sensibility, which is a composite of tingling or formication that comes from stimulating the hairs; the sensation of heat above 45 C.; sensation of cold below 20 C. All of these sensations are intense, with more diffuse and vehement reactions than occur in normal sensibility. These sensations, moreover, have in general a disagreeable or uncomfortable quality.

The capacity of localization in all qualities of "protopathic" sensibility is perverted, in that sensations radiate widely, are diffuse or else are referred remotely. "Protopathic" sensations are mediated by mechanisms which are distributed throughout the skin in a punctiform manner. Normally, these two systems of the skin function together—they supplement one another, and also have certain reciprocal relations as a result of which the "epicritic" system has an inhibitory effect on the "protopathic" system. Further, the latter system in general serves for the transmission of intense sensations which are only poorly localized, while the "epicritic" modifies this faulty localization and corrects it by partially inhibiting "protopathic" intensity and adding its own complements to sensation.

The evolutionary implication in Head's theory, however attractive and useful it may be as a generalization, does not receive the full support of known facts. If, as the theory presumes, "protopathic" sensation was the essential forerunner of later developments in the sensorium, the direct results of which were the further advancement of discriminative qualities in sensation, there are relatively few facts to support this view. Unquestionably, the "protopathic" sensation is inherently pro-

tective in its projicience. It depends on a widely radiating afferent inflow and a correspondingly diffuse efferent output. Its natural results tend to be mass reactions, distinctly unlike the discrete response determined by the "epicritic" inflow and its definitely discriminative projicience.

To consider these two components in any sense temporally independent or even objectively distinct would seem to contradict the very ends toward which animal organization directs its efforts. Certainly it would be difficult to conceive of any form of animal life, however low and simple its plan of organization, which could rely solely on a "protopathic" sensory equipment. Such an equipment, which would be inherently protective and implicit to a defense mechanism, would nevertheless be without the simultaneous operation of a directing sensory equipment to guide its efforts and make them adequately effective. One of these sensory components would be useless without the other, and it is equally true that no animal form exists in which the play of both of these sensory elements may not be readily discerned in all of its behavior. It seems clear in this light that any such priority in the evolutionary sense of a specific sensory quality is entirely out of the question. Furthermore, there seems little reason to draw any hard and fast boundary between two such presumptive types of sensation, since an intimate degree of mutuality and interchangeability actually exists between what is called "protopathic" and "epicritic." Any decisive cleavage between the two would seem impossible. Indeed, when such cleavage is made, it serves more the conveniences of nomenclature than the classification of known facts. This is all the more obvious when the very qualities of sensation which at one stage of development, either ontogenetic or phylogenetic, may be termed "protopathic" at a subsequent period show the characteristics of "epicritic" projicience.

Nor is the objection to this distinction founded alone on its failure to make a decisive and clearly defined contribution in the evolutionary sense. This interpretation seems to overlook well recognized clinical facts, facts indeed of common experience, which make clear that certain types of avowedly "protopathic" sensation may and often do rise to "epicritic" levels.

To maintain, therefore, that such sensory stimuli as pin-pricking, burning, freezing, electric irritation, plucking out of the hairs, or temperature above 45 C. and below 20 C., do not have discriminative qualities, seems wholly untenable. In the first place, some degree of discrimination or of localization adds an "epicritic" complement to all of these sensory impressions. In the second place, there is undeniably discrimination in the degree of discomfort caused by plucking out of a hair under different conditions; for example, the pain experienced in pulling out a hair from a normal hair follicle and from a follicle that is infected. The incision of an infected finger as compared with a

similar incision of a noninfected finger also reveals discriminative differences. Both the degree of discomfort and the localization of the pain imply "epicritic" activities associated with these painful stimuli. The theory which deprives pain sensibility of actual discriminative qualities cannot be valid in the light of common experience. This type of sensation may not possess the full range of "epicritic" associations inherent in the more highly discriminative sense of touch, but it does manifest so much of these qualifications as to deserve some place, however low, among the sensory qualities endowed with definite discrimination.

Head's theory of sensation, as Boring pointed out, may have its definite usefulness as applied to certain pathologic conditions, but beyond this it does not seem to have any real application. And yet there seems grave doubt to me whether this theory has justification even under pathologic conditions. How much of difference between his two types of sensation may be attributed to metabolic changes due to nerve cutting and regeneration must remain a question. The proposed distinctions may be based on phenomena of the traumatic procedure of operative intervention with the nerve and adjacent tissue. Furthermore, this distinction of "epicritic" and "protopathic" cannot be applied in testing the normal person, since, as Head clearly showed, there is only one place in the human body in which "protopathic" sensation exists, namely, in the glans penis. Thus, in the examination of normal persons, Head's distinction would be valid only in such a limited area as to make it of no value for purposes of sensory study.

Casting still further doubt on the validity of the theory which has brought into vogue the use of the terms "epicritic" and "protopathic" are the observations of certain investigators who have repeated Head's procedure of research and have been unable either to confirm his results or to bring themselves into agreement with his conclusions. Trotter and Davies, in many points, rejected Head's hypothesis, while Boring was more emphatic even than they in his refusal to accept it. Boring maintained that Head's subdivision of cutaneous sensibility into "protopathic" and "epicritic" is open to criticism not only because it is inconsistent in its evolutionary aspect with the hypothesis of the development of other modes of sensation but because it cannot replace other hypotheses of cutaneous sensibility since it is applicable only to a particular group of facts; also because it is not sufficiently thorough-going to constitute a true theoretical formulation; and finally, because it indicates generalities which admit of exceptions or are of doubtful nature.

It is for the reasons already cited that the terms "epicritic" and "protopathic" have been omitted from the sensory studies of Helen Keller. It seemed but fair, however, to discuss the reasons why they have been omitted.

More recent studies dealing with the nature of perception by Sir John Herbert Parsons maintain that the criticisms of Head's hypothesis do not invalidate the theory of the dual mechanism of sensation. Parsons has modified the theory by introducing a "dyscritic" mechanism on which an "epicritic" is superposed. At a still higher level he would introduce a "syncritic" mechanism subserved by the cerebral cortex and having the function of integrating "epicritic" phenomena. It is not clear that Parsons has done other than complicate an already overcomplex situation. The addition of these several new synthetic terms as recommended by him may be of great service for the purpose of graphic discourse, but there is little assurance that they offer any real assistance in the further interpretation of the facts. He did, however, recognize a cognitive element in the crude "protopathic," and this he preferred to call "dyscritic." As he would have it, the two components in the dual sensory system are, first, the "protopathic," now called "dyscritic," which is of vital import, and second, the "epicritic," of cognitive import. Applying these "dyscritic" and "epicritic" components to vision, as he would to all forms of somatic sensation, Parsons admitted that "dyscritic" vision has lost some of the characteristics of primitive "protopathic" sensibility and appears to have gained some "epicritic" characters in its manifestations in normal man. Moreover, it is not improbable that "dyscritic" vision may, under certain conditions, show some qualitative differentiations of "epicritic" vision. This admitted merging of one form of sensation into the other seems to make the fact obvious that the recognition of these two categories in the presumed dualism of sensory mechanism establishes a distinction without a difference.

Perhaps a more useful and certainly a much simpler form of nomenclature as applied to the sensations was that suggested by Kappers in his terms "vital" and "gnostic." Yet, as an interpretation of the phenomena involved in sensation, particularly as applied to cutaneous sensation, Boring's theoretical proposal seems to be most profound and comprehensive. In this proposal, he accepted the general principles of Bernstein's theory. This theory supposes that afferent nerves originating in adjacent regions of the skin through their functional actions are projected on adjacent regions of the sensorial nervous system. This is the principle of central projection. The theory also holds that the nervous impulse, while most effective at the point of its central projection, tends to spread to adjacent central regions. This is the principle of central diffusion. Boring concluded:

> The hypothesis more satisfactory than that of Head is one which assumes that single sensory spots are innervated by more than one nerve fiber; that this multiple innervation if projected upon the central nervous system as multiple excitations, multiple innervations, may furthermore be effective as summation or as inhibition of the excitations involved.

But in spite of the really stimulating influence of all of these theories concerning the nature of sensation, it must be admitted that they are all mere postulates based on a more or less adequately systematized introspection. The actual and measurable control of the factors entering into the processes of sensation extends but a short distance inward from the receptors and the receptor surfaces. Anything more than inference concerning the nature of these processes in the central nervous system is still beyond one's reach. And thus one theory may be as pleasing as another.

Boring's theoretical proposal, based on Bernstein's conception of the projection of adjacent cutaneous areas on adjacent regions of the cerebral cortex, although it disposes most effectually of the presumed dual mechanism of Head's theory, is none the less an admitted postulate which has not been proved by actual demonstration and which, as far as may be seen at present, is not susceptible of such proof. As for Head's dualistic conception of sensation, no recommendation may be made for its value in the study of sensation under normal conditions. Parsons' more recent modification of sensory dualism is an attractive and, to me, an alluring postulate. His "dyscritic" optic thalamus and "epicritic" cerebral cortex fit with such disquieting perfection into the diagrammatic schemas of sensory organization, as I long have hoped they might, that this very element of wish fulfilment makes me all the more skeptical of their validity!

It is undeniable, therefore, as Adrian contended in his recent communication, "The Basis of Sensation," that "there is an unsatisfactory gap between two such events as the sticking of a pin into my finger and the appearance of a sensation of pain in my consciousness. Part of the gap is obviously made up of events in my sensory nerves and brain and the psychological method by itself can tell me nothing at all about these two events." Adrian undertook to measure the passage of impulses conducted by sensory nerves. This proved to be possible because electric effects do occur in such nerves on stimulation of their end-organs. For estimating the passage of impulses along sensory nerves, Adrian employed the cathode ray tube in combination with a capillary electrometer and a three or four valve amplifier. By this means, he was able to detect action currents in nerve fibers leading from sense organs. Records were made of the discharge of sensory impulses produced by tension on a muscle, pressure, touch, movement of hairs, and pricking with a needle. In this manner sensory impulses, as they pass inward over a sensory nerve fiber, have been measured in their rate, intensity and rhythm, and also in regard to other functional aspects. Thus far one may trace the sensory nerve impulses with measurable certainty, but beyond this is still the expansive terra incognita into which they enter to form sensations the constitution of which it is not yet

possible to estimate or evaluate by any metrical or demonstrative method.

THE NATURE OF SENSATION

Whatever may be the objections to the several hypotheses concerning the nature of sensation, clinically it is not difficult to discern the general characteristics of discriminative sensibility which represents the assemblage of those sensory impressions having as their ultimate object the production of discretion and judgment.

In contrast to the qualities of discriminative sensibility are those sensory elements which go to make up affective sensibility. These are equally obvious. The latter portion of the sensorium enters into the various gradations of feeling tone. The impressions composing it produce changes in the general affect, altering it either favorably or unfavorably. But this more clinically practical conception of the sensorium also takes a too limited attitude toward the entire question of sensation. In fact, because it does leave the entire subject as a matter of sensation, it seems to miss the broadest biologic significance of the sensorium. Sensation as such might be regarded as a relatively negligible quality in the living organism, if it were not for the reactive turnover or effector responses which arise out of the senses. To leave the impressions from the outer world—by whatever avenue of approach they may have reached the nervous system—purely in the form of sensation overlooks entirely that conversion of energy for which the nervous system is primordially constructed.

It may be asked of what service would be the impression of sight, hearing, touch or pain, if it remained in the sensation phase and if it did not activate, direct or control some response or sequence of responses which had bearing on the process of living. Indeed, the entire realm of sensation justifies itself only if it is productive of adequate reactions. In this light, when the goal of sensation is regarded as reaction, the full biologic significance of all the impressions which enter the sensorium may be properly appreciated.

That modality long known as discriminative sensibility takes on the full dignity of its biologic importance when all impressions pertaining to it appear to have an inherently directive or guiding influence in the production of reaction. What is seen, no longer remains vision but is vision transformed into the productive and guiding effects of animal behavior. The same also is true of hearing which no longer occupies the physiologic aloofness of mere sensation, but becomes incorporated as a directing influence in the behavioral reactions of the animal. What is true of sight and hearing is also true of taste and smell, as it is likewise true of touch, pressure, temperature and vibration.

Thus, while it is possible to accept and recognize the accredited categories of discriminative and affective sensibility with certain critical reservations, these two sensory components seem to be vitalized and

made thoroughly dynamic by attributing to the former an inherently directive or guiding influence in reaction, and to the latter an equally inherent protective or guarding influence. The inherently directive influence of discriminative projicience is a primary and essential but not an exclusive quality of this type of sensibility. So, likewise, the protective quality in affective sensibility is both primary and essential but not exclusive. Either of these sensory modalities may under certain conditions operate in a protective or a directive capacity.

Considered, then, from a simple and objective point of view, the energy turnover which results in directive projicience depends on an afferent stream of impulses from the total environment, of which there are two major subdivisions: (1) body environment and (2) mundane environment.

According to this view, the nervous system is directly surrounded by the rest of the body and less directly by the outside world. The afferent flow from the body environment is composed of skeletal, muscular and visceral impulses, while from the mundane environment this inflow consists of impulses derived from physical and chemical contacts.

The visceral impulses from the body have not been investigated in this study and are included here merely for the sake of completeness in evaluating the total environment. The skeletal and muscular component of body sense, on the other hand, comprises two extremely important senses or sensory pathways, namely: (1) the muscle, bone, joint, tendon sense, and (2) the vestibular sense the end-organs of which are in the semicircular canals, utricle and saccule.

Sherrington proposed to call these two senses collectively the "proprioceptive" sense. Some objections may be urged against this term, especially since visceral sense is also definitely proprioceptive. It has seemed to me more direct and convenient to speak of those sensory elements pertaining to the muscles, bones and vestibular apparatus as the posture-motion sense. The chief sources of stimulation for the sensory inflow from these parts of the body are motion and posture. It is not difficult to appreciate the manner in which such impulses serve to direct the actions of the body.

Stimuli from the outside world contribute to the formation of the contact senses. This distinction permits of the following classification:

1. Chemical Contact Senses
   - (*a*) Smell
   - (*b*) Taste
2. Physical Contact Senses
   - (*a*) Touch
   - (*b*) Pressure
   - (*c*) Vibration
   - (*d*) Temperature
3. Distance Contact Senses
   - (*a*) Sight
   - (*b*) Hearing

The physical and chemical contact senses depend on stimuli which materially touch the body surfaces. The distance contact senses have their source of stimulation more or less distant from the body, and touch certain areas of it through the mediation of waves of light or of sound. It is probable that waves of other kinds touch the body, but this question opens a new field for speculation and research.

The necessity of sensations of sight, hearing, taste, smell, touch, pressure, temperature, vibration, motion and posture for guiding the actions of animals is easily appreciated from any study of vertebrate behavior. The service of such senses is therefore essentially and primarily directive.

The body and contact senses having a directive significance may be grouped as follows:

Body Sensibility	Contact Sensibility
I. Posture-motion sense	I. (*A*) Physical contact senses
1. Motion sense	1. Touch sense
2. Posture sense	2. Pressure sense
3. Balance sense	3. Vibratory sense
	4. Temperature sense
	(*B*) Chemical contact senses
	1. Smell sense
	2. Taste sense
	II. Distance contact senses
	1. Sight
	2. Hearing

Distinctions in this classification are based on the various types of stimuli adequate to the several different sensory components. In this, as in most attempts to be categorical, there are difficulties and objections. For example, all forms of contact stimuli touch the body immediately. Intermediacy is in reality figurative in that it indicates a source of stimulation more or less remote from the body, the stimuli from which require some medium such as light or sound waves to reach the receptors. For this reason, Sherrington distinguished between contact and distance receptors.

The sense of smell is another instance of difficulty in classification, for although the sense actually depends on a chemical relation between the olfactory receptors and the volatile stimuli, the source of the latter may be at a long distance from the body. Again, temperature sense may be stimulated by immediate contact with the body or by a source of heat at a considerable distance from the receptors.

Running through each of the components of sensation is a specific sensory quality which is essentially and primarily protective rather than directive. This quality is easily recognized in common experience. The stimuli which produce it are usually called "harmful." They cause

distress, discomfort or some feeling foreign to the normal sense of well being. They act as threats, warnings or signals of actual danger to the tissues of the body. Carried to extremes, they often become painful, but more often fail to reach this level of distress and produce a sense of annoyance only. The range of these stimuli embraces all degrees of discomfort from such actual pain to these slight annoyances, but the constant result of the energy turnover caused by them is some protective or guarding reaction. This sensory quality pervades all varieties of body and contact sense. It may be easily discerned in motion, posture and balance senses, as when joints are overflexed or overextended, or when extreme postures in limbs are too long maintained or the vestibular apparatus is overstimulated. It is developed by contact with extremes of heat or cold, sharp or rough surfaces, and by the application of severe pressure and heavy vibration. It also results from drastic chemical stimulation of taste and smell as well as from too great intensity of light or sound. It is proposed to designate this sense quality as the "harm" or "hurt" sense because its special import is either harmful or hurtful, and its reactive response is clearly protective. Numerous objections may properly be urged against the term, and I suggest its use only as a convenient expression until a better one is devised to embrace the observations resulting from certain sensory tests applied in this study.

A COMPARATIVE SENSORY ANALYSIS OF HELEN KELLER AND LAURA BRIDGMAN

II. ITS BEARING ON THE FURTHER DEVELOPMENT OF THE HUMAN BRAIN *

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It was my special problem in considering Helen Keller's sensory equipment to estimate as accurately as possible the value of the several senses contributing to her sensorium by which she gained an impression of her total environment. From her nineteenth month, she was blind and deaf. Her sense of smell, however, has been preserved and is of actual value to her in making contacts with the world. Her sense of taste is likewise preserved; it is, however, of much less value than the sense of smell but has not been without its benefits in her development. Being totally deprived of her visual and auditory senses, she depends primarily on her sense of touch.

A comparison between Helen Keller and Laura Bridgman has important bearing. Miss Bridgman was even more limited as to her sensory avenues than Miss Keller. She lived to be about 60 years of age. During infancy she suffered from severe convulsions. In her twenty-fourth month she had scarlet fever. Two older sisters died of the disease. Laura's eyes and ears suppurated, and sight as well as hearing was destroyed. Smell and taste were so nearly destroyed that both of these were almost useless to her during the greater part of her life. It is questionable whether at any time she had olfactory sense. Thus, Laura Bridgman made her adjustment to life with but one of the principal contact senses, namely, the sense of touch. Helen Keller, on the contrary, had the advantage of olfactory sensation and also somewhat of the sense of taste. The latter sensory avenue failed to open up much of the world to Miss Keller, but the sense of smell has proved to be of considerable importance in her intellectual development.

A brief history will suffice to establish Miss Keller's clinical background.

She was born, June 27, 1880, in Tuscumbia, a little town of northern Alabama. Her father's ancestry was Swiss. One of these Swiss ancestors was the first teacher of the deaf in Zurich and wrote a book on the subject of their education.

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Her mother was an Everett, belonging to the same family of Everetts as Edward Everett and Edward Everett Hale.

She was born healthy and remained so until in her nineteenth month, when she suffered from what was called "an acute congestion of the stomach and brain" which deprived her of sight and hearing. She had learned to say a few words, but these were soon entirely forgotten. And so as a result of her illness she became deaf, blind and dumb. When she was 6 years old, Dr. Alexander Graham Bell advised her father to write to the Perkins Institute for the Blind, in Boston, and ask for a competent teacher. In March, 1887, Miss Sullivan, now Mrs. Macy, came to Helen, in the beginning of her seventh year. Of this momentous event, Miss Keller writes: "Thus I came out of Egypt and stood before Sinai and a power divine touched my spirit and gave it light so that I beheld many wonders, and from the sacred mountain I heard a voice which said 'Knowledge is love and light and vision.'"

The truly marvelous results of education which Miss Keller has now made a matter of history were due to the ingenuity and wisdom of her teacher, Mrs. Macy, under whose tutelage she prepared for and entered Radcliffe College in the fall of 1900. She graduated with honors, and since that time her writings, her addresses and her efforts in behalf of those afflicted as she has been are among the notable achievements of modern civilization.

ANALYSIS OF HELEN KELLER'S SENSORY EQUIPMENT

To evaluate Miss Keller's sensory equipment, it is necessary to discuss each one of her senses separately. This discussion has as its main object a comparative study with presumably normal adults of approximately the same age as Miss Keller. For the purpose of making such comparison, it was necessary to establish certain means for measuring sensation in order that the measurements in the normal group might be compared with those of Miss Keller. In consequence, it was thought advisable to devise certain new instruments or to provide the application of certain modes of sensory stimulation, the degree of intensity or volume of which was measurable.

So far as possible, the tests applied in this study were metrical, and the figures obtained as a result of such measurements were made the basis of comparison. In dealing with each sensory component, two aspects of its sensory avenue were considered: (1) what may be called the subjective phase, or what the subject reports concerning this sense irrespective of the application of any tests, and (2) the objective phase, revealing what the subject reports as a result of special tests devised to stimulate this sensory pathway.

The Sense of Smell.—Beginning with Miss Keller's olfactory sense, the anatomic substratum of which is the first or olfactory cranial nerve, with its territories in the brain making up the rhinencephalon, the following facts have been brought to light: Miss Keller has an extremely sensitive olfactory sense. I may recite in this connection my experience

with her in a drive from her home in Forest Hills to Garden City, a distance of about twenty miles. The windows of the car were open. It was a fresh, crisp day in winter. I asked Miss Helen if she could tell me anything about the country through which we were passing, and her first observation was that we were then making our way through open fields. This proved to be the case, for the road ran through a golf course. Later, she said that we were passing trees. The road at this point made its way through a small grove. She then called attention to the fact that we had just passed a house with an open fire, and looking back I saw a small cottage with smoke pouring out of its chimney. She recognized at once when we turned off the main road to enter the Motor Parkway, and in the course of our drive along this road she declared that we were then passing a number of large buildings; looking behind me, I saw that we were actually in the vicinity of the several groups of structures constituting the Creedmore State Hospital for the Insane. In the course of our conversation concerning her olfactory sensitiveness, I asked Miss Keller if she would write out for me how important the sense of smell had been to her life and development. Shortly after this Miss Keller called attention to the fact that we had just entered Garden City and were passing the plant of Doubleday and Doran, her publishers, which actually was the case. Her realization of this fact, she told me, was due to her olfactory recognition of the ink from the presses of this publishing establishment with which she was familiar. In response to my request for some statement concerning her olfactory sense, Miss Keller wrote on the typewriter the following letter addressed to me, which is transcribed in full, not only as bearing on the point in question, but as showing the remarkable content of Miss Keller's mind, her literary appreciation, her phenomenal memory and her mastery of literature.

Forest Hills, L. I., N. Y., Feb. 8, 1928.

Dear Dr. Tilney:—Since our conversation last Saturday with regard to the importance of odors and vibrations in my life, I have remembered that I went into it quite fully in "The World I Live In." I asked Mrs. Henney to send you the book. You probably have it by now.

The sense of smell is the esthetic sense, I think, even more than sight. I know that odors give me a vivid conception of my surroundings. I call smell my landscape because, when I walk or drive through the country, so many odors tell me of fields, streams, honey-sweet valleys and hillsides covered with pines. If, as we are told, the ten thousand Greeks "shouted for joy when they saw the sea," I can imagine there must have been still more rejoicing when its bracing breath filled their nostrils.

How many memories, sad and bright, odors awaken in one's heart! Instantly a scent will carry one back through the years to a forgotten experience. A correspondent who had been with the "Princess Pat's Regiment" in France told me that once, after his return to America, the scent of trodden grass caused him to

faint, so forcibly had it brought to him the memory of being wounded, and lying with face downward on blood-soaked grass!

I am very sensitive to unpleasant odors. They have a depressing influence upon me; for they suggest all manner of dread things—disease, accidents, coming evil and unhappy lives. Sometimes, when such an odor comes between me and a beloved object, a nervous tremor seizes me, and I find it difficult to control myself.

In my reading I have found that the Russians and the French are very sensitive to the odors which bring me delight and pain. Shakespeare, too, is full of references to the olfactory sense. A number of passages occur to me which I will note: In the scene where Hamlet stands by the grave of Ophelia, and holds out the jester's skull to Horatio, he asks in effect, "Did not Alexander, think you, look like this on earth?" Horatio replies, "Even so," and Hamlet asks, "and smelt so?"

In "Macbeth," after the murder of Duncan, Lady Macbeth, gazing on her soft white hands, cries, "Out, damned spot! Out, I say. . . . Here's the smell of blood still; all the perfumes of Arabia will not sweeten this little hand." The smell-sensation, you see, is emphasized more than the sight of the blood-stain.

Juliet tells us

> "that which we call a rose
> Would by any other name smell as sweet."

Obviously, she is more impressed by the sweet smell of the rose than by its rich color or its exquisite petals.

When Juliet wonders what will become of her if she wakes in the tomb before Romeo comes, the odor-sense is skilfully employed to darken the picture:

> "Shall I not, then, be stifled in the vault,
> To whose foul mouth no healthsome air breathes in?
> . . . .
> Is it not like that I . . . with loathsome smells
> . . . shall be distraught?"

(I am quoting from memory.)

In "Twelfth Night" the Duke says of music

> "That strain again; it had a dying fall;
> Oh, it came o'er my ear like the sweet south
> That breathes upon a bank of violets
> Stealing and giving odor."

In these most poetic lines we have hearing and smell linked together aesthetically. The rich notes of the violin are associated in my mind with the emission of fragrance from dew-bathed southern roses in early June. I suppose the first poet called the scent of a flower its breath; but perhaps he did not realize as Bacon did that a breath is a sound. In his essay, "Of gardens," he says, "The breath of flowers is far sweeter in the air . . . where it comes and goes like the warbling of music . . . than in the hand."

In "Cymbeline" Iachimo describes the sleeping Imogen, and declares:

> "'Tis her breathing
> Perfumes the chamber thus."

In the summer-time, when all the windows in my eerie study are wide open, the scents from the flowers and trees in the garden beat upon me in little, delicately panting waves, and somehow this sensation is associated in my mind with the song of birds and the open sky.

I do not know of any passage in literature which so exquisitely interweaves all the senses as Shakespeare's sonnet XCIX. I will quote it because it illustrates how I interpret the sensations which come to others through the eye and the ear with smell.

> "The forward violet thus did I chide,
> 'Sweet thief, whence didst thou steal thy sweet smells.
> If not from my love's breath? The purple pride
> Which on my soft cheek for complexion dwells,
> In my love's veins thou hast too grossly dyed.
> The lily I condemned for thy hand,
> And buds of marjoram had stolen thy hair;
> The roses fearfully on thorns did stand,
> One blushing shame, another white despair,
> A third, nor red nor white, had stolen of both,
> And to his robbery had annex'd thy breath;
> But for this theft, in pride of all his growth,
> A vengeful canker eat him up to death.
> More flowers I noted, yet I none could see,
> But sweet or color it had stolen from thee.'"

You see why I stress the importance of the sense of smell. I associate it with poignant memories, deep emotions and the glories of poetry.

I recall a description I once read in French—unfortunately, I cannot remember the author's name—of a man who stood on the seashore with the wind blowing in his face, full of heart-stirring odors. He threw up his arms ecstatically, taking in great "mouthfuls of air," as the French idiom so vividly expresses it, while his heart overflowed with tender memories. The scents from land and ocean brought back to him the loved hearth of his boyhood where he had gazed into the fire, seeing magical pictures, the kisses of his mother, the fine, virile personality of his father, the orchard where he had played, and the summer nights when he wandered under the stars with great thoughts in his brain. Throughout the passage it is the sensation of smell, not sight or hearing, which awakens the deepest emotions.

I wonder how many people are aware of the complex odors in a house that has been lived in for a long time. They give me a comfortable sense of hospitality. They suggest cheery winter fires and peace and sweet family intimacies. There are lingering scents of perfume and garments in closets and drawers, and appetizing odors of cookery, which some people find extremely unpleasant, but which seem to me kindly.

Balzac attached much meaning to the smells that came to him while he worked in his attic. He was sensitive to the odor of brown gravy and the exhalations from the city streets. He read much of charm, and of ugliness, too, into the smell of garments and the cosmetics people used.

Pierre Loti noticed the odor of the crisp winter air in his mother's cloak when she came into the room where he lay ill, and bent over him, rosy-cheeked and drenched in sunshine.

I was much interested in an article by Stuart Mackenzie in "The American Magazine" entitled "Smells are Surer than Sounds and Sights." He notes among other things that plants emit many odors beside the perfume of their blossoms. Sometimes the scents are in the wood itself, as in cedar and sandalwood, sometimes in the bark, as in cinnamon and cassia, or in the leaves, as in pines, bay, mint, thyme and lemon verbena. Others are in the fruits—orange, lemon and

nutmeg. He has observed smells also in the seeds—almond and caraway, and I would add magnolia-seeds, and sometimes certain secretions are fragrant, like turpentine, and even roots have a strong odor, like the orris root. All this knowledge is a part of my equipment for getting joy out of life.

Mr. Mackenzie also says that he felt keenly his inferiority in the olfactory sense when he lived among some Western Indians. They could detect a distant camp-fire when he could not possibly perceive it. This makes me feel my kinship to the Indians; for I, also, can smell at a great distance.

Some day, when I have leisure, I will write you more on this fascinating subject. The Bible is crammed full of odor references. The patriarchal services had in them much of incense and sweet oil. If the elders who stand around the Throne of God hold in one hand golden harps, they hold in the other "Golden vials full of odours which are the prayers of the saints."

Sincerely and interestedly yours,

HELEN KELLER.

When tested objectively, Miss Keller's olfactory sense shows nothing above the normal average. Six aromatic substances were used in these tests, including alcohol, oil of wintergreen, peppermint, formaldehyde, eucalyptus and asafetida, with the results recorded in table 1.

TABLE 1.—*Estimation of Olfactory Sense* *

	Did Not Recognize	Recognized
Alcohol	1 to 32	1 to 16
Wintergreen	1 to 256	1 to 128
Formaldehyde	1 to 32	1 to 16
Peppermint	1 to 2048	1 to 1024
Eucalyptus	1 to 128	1 to 64
Asafetida	1 to 4096	1 to 2048

* Miss Keller's responses to olfactory tests correspond closely to the normal average.

In consequence of these tests, it may be said that the fundamental pathway for the sense of smell in Miss Keller does not have a demonstrable advantage in its peripheral organization.

The Sense of Taste.—Gustatory sense, a specialized portion of the seventh and ninth cranial nerves, also did not show any advantage in its fundamental organization.

The Sense of Sight.—Concerning vision, it may be said that Miss Keller is totally blind and has been in that condition since her nineteenth month. She can perceive neither light nor objects. Both retinae are absent. She therefore is deprived of the primary conduction paths for visual sense.

The Sense of Hearing.—With reference to the auditory sense, Miss Keller is completely deaf, having neither bone nor air conduction in either ear. Concerning her bone conduction, some question might arise as she is conscious of vibratory impressions. This, however, is in all probability due not to her auditory sense, but rather to an extraordinary development of her vibratory sensibility.

The Sense of Touch.—The analysis of Miss Keller's capacities in the sense of touch has been most carefully studied, and many measurements have been made by repeated testing. In these examinations, much care was exercised to prevent that fatigue which so commonly makes its appearance after the subject has been under observation for some time. When there was any doubt as to the figures obtained by these sensory measurements, they were repeated on another day. In fact, all of the estimations have been checked by frequent retesting. Sometimes the retest was made by the original observer, but just as often by a collaborator. Ultimately, an average figure was obtained from these several controls of each test.

Light Touch: The test for light touch was made by means of graded bristles corresponding with the von Frey instruments of this kind.

TABLE 2.—*Estimation of Light Point Touch* *

	Right Side of Face †				Left Side of Face			
Helen Keller	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
	Right Forearm ‡—Ventral				Left Forearm—Ventral			
Helen Keller	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
	Right Finger Tips—Palmar				Left Finger Tips—Palmar			
Helen Keller	0.4/10	0.3/10	0.03/2	0.01/0	0.4/10	0.3/10	0.03/4	0.01/0
Average	0.4/10	0.3/10	0.03/6	0.01/2	0.4/10	0.3/10	0.03/6	0.01/0
	Right Fingers—Dorsal				Left Fingers—Dorsal			
Helen Keller	0.4/10	0.3/10	0.03/10	0.01/4	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5

* Bristles in fractions of gram of tensile resistance. The denominator indicates correct responses in ten tests. The numerator indicates the bristle employed.
† "Side of face" includes four areas: forehead, supra-orbital region, cheek and chin.
‡ "Forearm" includes two areas: (a) elbow and (b) middle of forearm.

In so far as possible, the methods of cutaneous sensory testing employed by previous observers have been applied to Miss Keller. This refers not only to the type of instrument used but to the rules regulating the tests. In examining the state of cutaneous sensibility dependent on light touch, or what might be called "point touch," as the stimulus is limited to single points on the skin, a group of four bristles was employed. These bristles were numbered 1, 2, 3, 4, respectively. No. 1 had a tensile resistance of 0.4 Gm.; no. 2, a tensile resistance of 0.3 Gm.; no. 3, of 0.03 Gm., and no. 4, of 0.01 Gm.

Each bristle was applied to each point tested ten times successively, and the number of correct answers was noted for each bristle. In these tests, Miss Keller showed that she corresponded to the normal average in an exact and striking manner. The summary of these comparative tests is given in table 2.

Two-Point Recognition: The recognition of two points placed simultaneously on the skin is probably not merely confined to the operation of cutaneous receptors, but undoubtedly is influenced by the deeper receiving organs essential to the recognition of pressure. Two-point recognition, moreover, belongs unquestionably to a type of sensory organization requiring a higher level of cortical activity than that necessary for light touch. Indeed, it is a question in my mind whether two-point differentiation on the skin should not be considered as a higher sensory synthesis, particularly since it shows considerable variation in persons subjected to different degrees of training. This view may suffice to explain the discrepancies in observation made on different subjects. The instrument used for these tests was a pair of exactly calibrated calipers, the sharp points of which were slightly ground down to avoid producing pinpoint stimulation. Similar calipers with pointed ends were also employed as a control, but the figures obtained from them have not been tabulated since it appeared that the pressure elements of sensation entered too much into such tests. Dr. Byron Stookey's two-point esthesiometer was also employed in checking the observations made by other instruments. For practical purposes, it is the most convenient instrument for studies in two-point recognition.

In comparing Miss Keller's two-point tests with those of the normal person as averaged from ten normal subjects tested, there appeared to be no essential difference. Miss Keller's two-point recognition was the same as the normal average. This fact seems to be particularly interesting, since Dr. G. Stanley Hall, in consequence of similar tests of Laura Bridgman, found that she possessed a two-point recognition two or three times greater than that of the average person. My own experience with Miss Keller leads to some question as to the validity of Dr. Hall's conclusion, for in comparing figures which I have obtained with Helen Keller, I find that they correspond with remarkable closeness to those recorded for Laura Bridgman. As has been stated, Miss Keller herself is quite similar to the average normal adult; in fact, one blind girl whom I tested had a much greater acuity in two-point recognition than Miss Keller. Dr. Hall noted that Miss Bridgman could detect a distance of 0.5 mm. on the tip of her tongue; Miss Keller could do this also, and indeed it is possible for many normal adults.

In the tests of two-point recognition Miss Keller was able to detect the eye of a needle by applying the latter to the tip of her tongue and, having done so, she finally succeeded in introducing a thread into the eye after a period of concentration and—as she expresses it—patience. This same concentration and patience are, I believe, the secret of much of Miss Keller's sensory superiority.

As bearing on the differences between Laura Bridgman and Helen Keller in two-point recognition, there is a fact which seems to support

the postulate already made, namely, that this form of sensation belongs to the higher orders of sensory syntheses, and is largely conditioned by training. For many years Miss Bridgman employed most of her spare time in doing needlework for pin money. She made much beautiful embroidery and developed great facility with her needle. This continued use of so fine an instrument as the needle would have served to train her two-point recognition to an extraordinary degree.* It might be presumed that reading braille would similarly train two-point recognition, but the braille points are relatively coarse and the intervals between them are not small, so that such an exercise would not necessarily develop a high degree of sensory synthesis in two-point recognition, although Miss Keller is an untiring reader. She uses the typewriter a great deal, but she has not cultivated her needlework to the extent that Laura Bridgman

TABLE 3.—*Estimation of Two-Point Touch Recognition* *

	Right			Left		
	Forehead	Cheek	Chin	Forehead	Cheek	Chin
Helen Keller.....	1.25	1.25	1.0	1.25	1.25	1.0
Average.....	1.50	1.50	1.0	1.50	1.50	1.0
	Arm	Forearm	Palm	Arm	Forearm	Palm
Helen Keller.....	7.50	5.00	3.0	7.50	5.00	3.0
Average.....	8.00	5.00	3.0	8.00	5.00	3.0
	Thumb	Finger	Thigh	Thumb	Finger	Thigh
Helen Keller.....	1.00	1.00	25.0	1.00	1.25	25.0
Average.....	1.25	1.25	25.0	1.25	1.25	25.0
	Calf	Foot	Toes	Calf	Foot	Toes
Helen Keller.....	20.00	5.00	1.5	20.00	5.00	1.5
Average.....	22.00	5.00	1.5	22.00	5.00	1.5

* The separation distance is expressed in millimeters.

did. It is on the grounds of this special training to which Miss Bridgman subjected herself that I attribute the difference in her two-point recognition which Dr. Hall claims was two or three times better than the normal average, and it is to the lack of such intensive training that I would attribute Miss Keller's less highly developed two-point recognition. I should feel that a two-point recognition two or three times greater than the normal, as Miss Bridgman's was said to be, is perhaps only approximate and may give a somewhat exaggerated idea of her actual capacities in this form of sensory perception.

It is my conclusion that Helen Keller does not show any advantage in two-point recognition over the normal average, and such advantage as Laura Bridgman is said to have manifested should be ascribed to special training in the associations of this complex sensory synthesis.

A comparative summary of Miss Keller's two-point touch recognition is given in table 3.

Touch Localization: In the tests of touch localization, it was necessary to employ a somewhat specialized method in order to obtain clear responses from Miss Keller. To do so, I asked her to indicate on the surface of the skin the point where I touched her. The observer employed a fine pencil point of soft lead. Miss Keller herself also used a similar lead pencil. The point touched by the observer left a small black dot on the skin. In endeavoring to locate this point Miss Keller's pencil also left a dot on the skin. The distance between these two points was measured to show the error in exact localization. The same method was employed in testing the normal adult controls. There is always considerable error in this touch localization, varying in the normal person from 3 to 25 mm. or more, depending on the area. Miss Keller's margin of error was no greater and no less than that of the average.

TABLE 4.—*Estimation of Touch Localization*

	Right			Left		
	Forehead	Face	Chin	Forehead	Face	Chin
Helen Keller	4.0	3.0	3.0	4.0	3.0	3.0
Average	3.5	3.0	2.5	3.5	3.0	2.5
	Shoulder	Arm	Forearm	Shoulder	Arm	Forearm
Helen Keller	25.0	22.0	20.0	25.0	22.0	20.0
Average	22.0	20.0	20.0	22.0	20.0	20.0
	Palm	Thumb	Fingers	Palm	Thumb	Fingers
Helen Keller	4.0	4.0	4.0	4.0	4.0	4.0
Average	4.0	4.0	4.0	4.0	4.0	4.0
	Knee	Calf	Foot	Knee	Calf	Foot
Helen Keller	25.0	25.0	15.0	25.0	25.0	15.0
Average	25.0	25.0	15.0	25.0	25.0	15.0

In evaluating touch localization, it must be regarded as a fairly high degree of tactile discrimination. It certainly involves more than the cutaneous receptors, especially as the test was devised and applied in this study. The pressure sense entered into the sensory syntheses necessary to the sensation. Such stimuli are essential to touch localization if it becomes accurate, although light touch may be fairly well localized, as, for example, the crawling of an insect over the skin. But I have noticed in myself that localization unaided by vision has a somewhat wider margin of error than when a certain degree of pressure enters the synthesis. My conclusion, therefore, is that the most accurate touch localization depends on subcutaneous receptors cooperating with those in the skin itself.

The summary of Miss Keller's touch localization in several parts of her body is given in table 4.

Testing Cutaneous Sense by Electric Currents: One of the most useful and accurate means of testing skin sensation is by the use of a small examining electrode (1 cm. in diameter) by the aid of which a

faradic current is applied to different parts of the body. I have standardized this means of testing through many examinations, using an inductorium of 1,000 coils over the primary, and estimating the point of sensory perception in centimeters of coil distance over this primary. The results of tests of Miss Keller over different areas are in close accord with those of the normal average person. The summary of these tests is given in table 5.

The galvanic current was also employed in estimating the acuity of skin sensation. The records were here made in milliamperes from the cathode applied as the examining electrode. In these tests, Miss Keller corresponded closely with the normal average.

TABLE 5.—*Estimation of Faradic Touch—Induction, 1,000 Coils* *

	Right Ventral Surface			Left Ventral Surface		
	Neck	Arm	Wrist	Neck	Arm	Wrist
Helen Keller.....	2.2	4.0	3.9	2.2	4.2	3.9
Average.....	2.5	4.0	3.5	2.5	4.0	3.5
	Right Dorsal Surface			Left Dorsal Surface		
	Neck	Arm	Wrist	Neck	Arm	Wrist
Helen Keller.....	2.2	3.6	3.0	2.2	2.6	3.0
Average.....	2.5	3.0	3.0	2.5	3.0	3.0

	Right Finger Tips—Palmar					Left Finger Tips—Palmar				
Helen Keller.....	3.3	3.0	3.0	2.6	2.4	3.0	3.0	2.7	2.7	2.1
Average.....	3.0	3.0	2.5	2.5	2.5	3.0	3.0	2.5	2.5	2.5
	Right Fingers—Dorsum					Left Fingers—Dorsum				
Helen Keller.....	3.8	3.5	4.0	3.2	4.0	3.6	3.4	3.5	3.2	3.5
Average.....	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5

* Estimated in centimeters of coil distance.

Pressure Sense: Tests were made by means of a pesometer in which the differentiation in focal pressure on the points of the skin was estimated in grams. The diameter of the surface applied to the skin in the pesometer used was 1 mm. As a result of these tests, Miss Keller was found to correspond accurately to the normal average adult. A summary of focal pressure differentiation in grams is given in table 6.

Surface pressure was measured as compression by means of a cuff in connection with a manometer, the pressure being recorded in millimeters of mercury. These compression tests gave the following results:

In increase in pressure of from 10 up to 40 mm. a rise of 1 mm. and a fall of 2 mm. were detected on both arms, forearms and hands. A rise of 1 mm. and a fall of 2.5 mm. were detected on both thighs. A rise of 2 mm. and a fall of 1 mm. were detected in both legs at about the middle of the calf. In compression tests in which the mercury column rose from 40 to 140 mm., the interval of differentiation was somewhat

wider. On both arms, forearms and hands a rise of 5 mm. and a fall of 10 mm. were detected. In both thighs and legs a rise of 5 mm. and a fall of 10 mm. were appreciated. These tests as applied to Miss Keller gave results with which the control tests in ten normal adults corresponded with such minor variations that the differences were negligible. In other words, the measurements of Miss Keller's pressure sense by compression were similar to those of the normal average.

Temperature Sense: The temperature component of contact sense has always created great difficulties in metrical estimation. The procedure followed in evaluating this type of sensibility in Miss Keller was a series of tests by means of electric thermophores. Two thermophores were used, each set at a different temperature. Each was maintained

TABLE 6.—*Summary of Focal Pressure Differentiation (in Grams)*

	Right			Left		
	Upper Part of Face	Lower Part of Face	Shoulder	Upper Part of Face	Lower Part of Face	Shoulder
Helen Keller	3.2	3.5	9.4	3.2	3.2	9.4
Average	3.5	3.5	9.0	3.5	3.5	9.0
	Arm	Forearm	Palm	Arm	Forearm	Palm
Helen Keller	9.0	8.4	6.4	9.0	8.2	6.4
Average	9.4	8.0	6.0	9.4	8.0	6.0
	Back of Arm	Back of Forearm	Back of Head	Back of Arm	Back of Forearm	Back of Head
Helen Keller	9.4	9.4	7.25	9.4	9.4	9.4
Average	9.4	9.4	9.4	9.0	9.4	9.4
	Fore-finger	Middle Finger	Ring Finger	Fore-finger	Middle Finger	Ring Finger
Helen Keller	5.2	5.2	5.2	5.2	5.2	5.2
Average	5.2	5.2	5.2	5.2	5.2	5.2

constant by means of an adjustable rheostat. The surface applicator was circular and measured 5 mm. in diameter. One thermophore was set at 98.5 F. and the other at 100 F. The applicator was allowed to remain on the skin for four seconds; an interval of four seconds elapsed before the second application was made, during which the applicator was held in position for four seconds also. It was found that neither Miss Keller nor any of the normal adult controls was able to distinguish less than 1.5 degrees F. in the most sensitive parts of the body. The two thermophores applied in the manner indicated to the forehead, cheek and chin of both sides, to five areas on the arm and forearm, to six areas of the palmar and dorsal surfaces of the hand, to each phalanx of all of the fingers on both sides and to two areas on the chest and on the abdomen, gave prompt and accurate responses. Two areas on the thigh, the calf and the dorsum of the foot gave accurate but somewhat hesitating responses on both sides. With the thermophores set at 120 and 110 F.,

respectively, following the same method of testing over the same areas indicated in the previous tests, the responses obtained were all prompt and accurate except on the back of both thighs where there was considerable hesitation, but a response which eventually was accurate. In all of these tests, Miss Keller corresponded closely with the normal average adult controls (table 7).

Vibratory Sense: The vibratory component of sensibility was also measured. In this connection, it should be noted that this sense is by no means dependent alone on bone for its ultimate conduction. Vibration is easily felt on the skin, as when applied on the web between the thumb and the index finger or other fingers. Vibration may be perceived on regions of loose skin picked up between the thumb and finger, without the intervention of the bony system. Vibration sense plays an extremely

TABLE 7.—*Temperature Discrimination Estimated by Thermophores* *

	Right			Left		
	Cheek	Neck	Shoulder	Cheek	Neck	Shoulder
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average.....	1.5	1.7	1.5	1.5	1.7	1.5
	Arm	Forearm	Palm	Arm	Forearm	Palm
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average.....	1.5	1.5	1.5	1.5	1.5	1.5
	Fingers	Chest	Abdomen	Fingers	Chest	Abdomen
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average.....	1.5	1.5	1.4	1.5	1.5	1.4
	Thigh	Leg	Foot	Thigh	Leg	Foot
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average.....	1.4	2.0	2.0	1.4	2.0	2.0

The estimations made were in degrees Fahrenheit between 98.5 and 100.

important rôle in the information that it conveys to Miss Keller. She is able to distinguish much that is going on in the household through this sensory avenue. When she is in her study writing, meal time is announced to her by some one stamping on the floor in the dining room. She is able to recognize this stimulus on the floor above. To a certain extent she can distinguish different persons by their tread on the stairs or on the floor. Seated in her own room, she is able to recognize the flight of airplanes passing in the vicinity of her home. This, of course, is an example of vibration transmitted to the body through the air from a distant source of stimulation. It illustrates some of the inconsistency in regarding vibratory sense as restricted to actual contact sensibility. Miss Keller is also able to recognize the difference between the vibrations produced by implements used in the house, such as sawing, planing or hammering; but her most remarkable development in vibratory perception is her latest achievement of "listening" to the radio by means of

her hands. A special loud speaker has been constructed for her under the direction of Mr. Keith Henney. Miss Keller finds much enjoyment in the radio programs which she hears in this way. Up to the present time she has not learned to interpret spoken language on the radio, but she has a keen appreciation of music and is able to distinguish different selections which she has previously heard. She gives evidence of her musical appreciation by her change of expression. Slow and sad music causes a serious expression. Quick music and dance music cause her to manifest rhythmic actions characteristic of dancing. Another remarkable achievement in utilizing the vibratory sense is seen in her ability to interpret spoken language by placing her hand on the face of the speaker so that the thumb rests on the larynx, the middle finger on the lips and the index finger on the ala of the nose. Thus she distinguishes the vibratory effects of articulation and can follow conversation with ease. An interesting picture showing Miss Keller thus engaged appears in one of her books, "The Story of My Life." Here she is shown conversing with Mr. Joseph Jefferson and her teacher, Mrs. Macy. They are apparently holding an animated conversation in which Helen Keller is not the least enthusiastic participant.

In testing Miss Keller's vibratory sense, two metrical procedures were employed: The first was the application of tuning forks with 128, 256, 512, 1,024 and 2,048 vibrations, respectively. The highest vibration that Miss Keller was able to perceive by this means in any part of her body was 1,024 (high *C*), but for most areas of her body her highest range was 512 (C_2). The second procedure employed was the Henney pallesthesiometer, which records on a scale of radio cycles. This is a new instrument, especially devised for measuring Miss Keller's vibratory perception and for which I am indebted to Mr. Keith Henney. It is extremely delicate and gives with great accuracy the upper and lower ranges of vibratory sensation received from all parts of the body.

A third method was employed for testing surface vibration, in which vibratory sensation over large areas of the body was examined by an especially devised loud speaker mechanism attached to the pallesthesiometer. In all of these tests, Miss Keller's range of vibratory sense corresponds strikingly to that of the normal average.

A summary of vibratory sense as tested by tuning forks and the pallesthesiometer is given in tables 8 and 9.

Motion Sense: In the next observations, tests were made of postural and motion sense. The first of these was the actual measuring of motion sense for which a new instrument was designed, called the "kinemometer." This instrument is so arranged that it is capable of measuring changes in the limbs or parts of the limbs in millimeters. It consists of a platform on which the part to be studied may be placed.

The platform itself may be elevated or depressed by means of a delicately adjusted worm-screw and the distance of such motion measured in millimeters. The movable platform is so divided that the entire limb, the hand, or each finger, as well as the several joints of the finger, may be moved separately and the range of motion perception thus recorded.

TABLE 8.—*Estimation of Vibration Sense by Tuning Forks* *

	Right			Left		
	Upper Part of Face	Middle Part of Face	Lower Port of Face	Upper Part of Face	Middle Part of Face	Lower Port of Face
Helen Keller.....	1,024	1,024	1,024	1,024	1,024	1,024
Average.....	1,024	1,024	1,024	1,024	1,024	1,024
	Occiput	Acromion	Olecranon	Occiput	Acromion	Olecranon
Helen Keller.....	1,024	1,024	1,024	1,024	1,024	1,024
Average.....	1,024	1,024	1,024	1,024	1,024	1,024
	Carpus	Fingers	Spine	Carpus	Fingers	Spine
Helen Keller.....	1,024	1,024	512	1,024	1,024	512
Average.....	1,024	1,024	512	1,024	1,024	512
	Knee	Shin	Ankle	Knee	Shin	Ankle
Helen Keller.....	512	512	512	512	512	512
Average.....	512	512	512	512	512	512

* Oscillations indicate 1,024 (C^8), 512 (C^2).

TABLE 9.—*Focal Vibration Sense Measured by Pallesthesiometer in Radio Cycles*

	Right			Left		
	Mastoid	Neck	Shoulder	Mastoid	Neck	Shoulder
Helen Keller.....	1,100	1,100	1,100	1,100	1,100	1,100
Average.....	1,100	1,100	1,100	1,100	1,100	1,100
	Occiput	Scapula	Elbow	Occiput	Scapula	Elbow
Helen Keller.....	1,600	1,100	900	1,600	1,100	900
Average.....	1,600	1,100	1,000	1,600	1,100	1,000
	Forearm	Wrist	Palm	Forearm	Wrist	Palm
Helen Keller.....	1,300	1,000	1,600	1,300	1,000	1,700
Average.....	1,300	1,100	1,600	1,300	1,100	1,600
	Thumb	Fingers	Shin	Thumb	Fingers	Shin
Helen Keller.....	1,400	1,400	520	1,400	1,400	520
Average.....	1,400	1,400	520	1,400	1,400	520

The summary of motion sense measured in millimeters is given in table 10. From these tests, it is evident that Miss Keller is, if anything, less acute in the recognition of motion than the average normal adult.

Posture Sense: Posture sense was measured by means of the kinemometer, and it was found that postures of the hand, fingers and arms were accurately appreciated by Miss Keller, although she did not show a greater capacity in this respect than the normal average.

Balance Sense: The estimation of balance sense was made by means of a rotation chair, by the Romberg position, by rotation in the standing position and by the Hitzig galvanic stimulation of the vestibule. Miss Keller showed on rotation that she did not possess a sense of direction. The rotation did not cause visceral sensation of any variety. The test of rotation for nystagmus was omitted, as certain ocular operations precluded such reactions. It is interesting in this connection to note again that Miss Keller does not possess retinas, and this, in conjunction with the fact that she is devoid of any sense of direction, may have an important bearing on certain but little understood sensory pathways connected with the eye. After repeated tests in the rotation chair, Miss Keller was

TABLE 10.—*Estimation of Motion Sense* *

	Right Joint Flexion			Left Joint Flexion		
	Elbow	Wrist	Thumb	Elbow	Wrist	Thumb
Helen Keller.....	3	3	3	3	3	3
Average.....	2+	2+	2+	2+	2+	2+
	Right Joint Extension			Left Joint Extension		
	Elbow	Wrist	Thumb	Elbow	Wrist	Thumb
Helen Keller.....	2	2	2	2	2	2
Average.....	1+	1+	1+	1+	1+	1+
	Right Joint Flexion			Left Joint Flexion		
	First Phalanx	Second Phalanx	Third Phalanx	First Phalanx	Second Phalanx	Third Phalanx
Helen Keller.....	3	3	3	3	3	3
Average.....	2+	2+	2+	2+	2+	2+
	Right Joint Extension			Left Joint Extension		
	First Phalanx	Second Phalanx	Third Phalanx	First Phalanx	Second Phalanx	Third Phalanx
Helen Keller.....	2	2	2	2	2	2
Average.....	1+	1+	1+	1+	1+	1+

* This sense was measured in millimeters by the kinemometer.

able to designate with a certain degree of accuracy the direction in which she was being moved. She believed that her perception in this regard might be explained by air currents striking her face as the chair rotated in one direction or the other. Her spatial orientation in limb movement and general coordination was perfect. This was determined by tests for nonequilibratory as well as equilibratory coordination. Miss Keller was found to possess a perfect sense of balance, in spite of the fact that there was no response from the semicircular canals of either side to cathodal or anodal stimulation of the Hitzig tests. I refrained from making the caloric tests during this series of observations, but for completeness I hope to add them in a subsequent report.

The Hurt Sense: Analysis of the hurt sense showed that to the pin point measured by the algesimeter in millimeters, to steady pres-

sure, to sudden compression, to extremes of temperature, to vibrations below 100 oscillations, to overextension or overflexion of joints, Miss Keller's discomfort was essentially the same as that in the normal controls. The algesimeter applied to the fingers (all of the phalanges) and to the same area of both palms, to the back of the hand, to the forearm and arm, to the entire face on both sides and to the leg and foot gave the same rating for Miss Keller as for normal adults.

Overextension of the wrist and the several joints of each finger of both hands caused discomfort at the same degree of extension as in the normal. Temperature at 110 F. was uncomfortable and at 120, disagreeable and tending to be painful. Steady thrusts at a pressure of 10 pounds on the back of either hand became disagreeable and if continued for several seconds, almost painful. Compression on both arms and forearms, as well as on both legs, at 130 mm. of mercury became uncomfortable, and at 150 mm. became disagreeable and painful. It is possible that if Miss Keller's hurt sense is actually less acute than in the normal person, this difference may be explained by the fact that there is a degree of stoicism in her philosophy which permits her to endure pain and distress with more fortitude than most normal persons possess.

SENSORY SYNTHESES

It seems likely that the several components of contact sense are seldom employed singly. Most of one's contacts with the world depend on various combinations of these several contact components. For example, the recognition of different states of matter such as fluidity, viscosity or solidity depends on stimuli of surface touch, spreading touch, surface and spreading pressure and surface temperature, as well as motion in the several parts making the contact. Not only must these elements enter into a sensory composite which gives the actual picture of the situation examined, but almost photographic memory of these conditions must be made and retained in the brain. Correlation with other types of sensation is also essential in order to permit of proper object association, recognition and naming. The texture, the size and the shape of objects with which one comes in contact through the sense of touch likewise require composite associations of the several sensory elements. One of the most important of these composites is the recognition of objects by palpation, the sensory process of which is called stereognosis. In this capacity, Miss Keller showed an extraordinary richness of association dependent on many sensory qualities derived from surface touch, surface pressure, surface vibration and surface temperature in combination with sensory elements of motion and posture. Miss Keller's stereognosis is much above that of any normal person whom I have ever tested. Not only is she able to recognize all familiar objects about her, to tell the form and size of many articles with which she has not

had previous contact, but she also has the ability to identify by touch the difference between a great variety of flowers and plants. This is a feat far above the capacity of most average persons even when aided by all of the senses. After testing her capacity for the recognition of form with many different objects, I placed in her hand a coin, telling her that this was the one touch of nature which made all men kin. Her immediate answer was—"Pessimist." Such a response showed not merely a great rapidity in the assemblage of sensory associations related to touch but an equally quick wit and broad understanding of the world.

Miss Keller's sensory organization for the primary conduction of afferent impulses thus does not appear to be different from that of the average run of humanity. Her sensory supremacy is entirely in the realm of intellect. Here she has developed a richness of association far surpassing that of the average adult. She seems to be exceptionally capable even for the class rated as intellectual.

SENSORY DEVELOPMENT OF LAURA BRIDGMAN

A comparison of Miss Keller's sensory equipment with that of Miss Laura Bridgman is important since all of the conclusions drawn from Miss Keller gain substantiation from this comparative study. During her life, Laura Bridgman was the subject of careful examination by Dr. G. Stanley Hall, who recorded the results of his investigations in 1879.

She was born in Hanover, N. H., in 1829, and died in 1889. Her family were farming people of sound health, good habits and average height. Both parents were rather nervous. Miss Bridgman's mother had an active mind. Laura is said to have inherited the physical peculiarities of her mother. She had convulsions during infancy and was quite delicate. When 24 months of age, she had a severe attack of scarlet fever. Both of her eyes and her ears suppurated. She was kept in a darkened room after this sickness, and was so feeble for two years that she could not sit up unsupported. The illness left her deaf and blind and, to a great extent, deprived of smell and taste. The sight in the left eye was entirely lost. With the right eye she perceived some sensation from large and bright objects up to her eighth year, but after that time she was completely blind. When she was 5 years of age, her strength began to return, and toward the end of her eighth year she was sent to Dr. Howe, of the Perkins Institute, in order that she might be educated. As a result of her long illness, all recollections of babyhood had been effaced. Before her education was seriously undertaken, she had received some training at home. She was able to do a little sewing, knitting and other household tasks. Her parents kept her as much as possible in the sunlight, so much indeed that she often complained of a slight pricking like that of needles in the left eye. She always wore a band of green silk over her eyes. In her early years at home she became familiar with the objects about her, as to their form, weight, density and temperature. Dr. Hall believed that only most elementary impressions from the sense of sight could have helped with her mental growth. She seems to have had some conventional notions of color in which she took great interest. It is believed that by her delicacy of touch she could distin-

guish green and white squares; yet on actual testing, she had no real idea of color. Dr. Hall believed that she was less blind-minded than many of the congenitally blind.

When she was 10 years of age, she wrote her name legibly for the first time. She then revisited her home, recognized her father at once by touch, tasted and recognized her mother's cooking, and taught her mother the finger alphabet. She had an astonishing accuracy in measuring time, as it seemed, by intuition. She did not possess a watch until much later. Her sense of touch at this age was acute, even for the blind. It was difficult to pass her in the hall without being recognized. Her judgment of distance was extremely accurate, and she continually practiced in feeling the objects about her. When she was 12 she developed the ability of knowing when any one touched the piano in the same room. She said the sound came through the floor to her foot and up to her head. Many of those about her thought that she was possessed of the sixth sense. It was never necessary for her to feel or grope her way about. In all her goings and comings she went straight like a bee, seeming to possess a remarkable sense of direction. She was so sensitive to vibrations that when the bell of the Perkins Institute was out of order she, who had never heard it, missed its vibrations more than anyone else.

During most of her adult life she was able to sew by hand and on the machine, and did much work of this kind. Her education, undertaken by Dr. Howe, led him to surround her with many restrictions, the psychologic justification of which may be questioned in the present day. He never permitted her to be fondled or caressed. He would not allow her to associate with boys or men and even in his own contacts with her he was most circumspect, avoiding anything but the most limited expressions of approval or disapproval. The theory which dictated this course of Dr. Howe's had its origin in the belief that all stimuli which might engender or arouse sexual feeling should be rigorously excluded. The result of these restrictions was a life very much shut in, one characterized by not a little prudishness and eccentricity. In this respect Laura's training differed greatly from that employed by Mrs. Macy with Helen Keller. Miss Keller's quick and happy responses, her brightness and charm in all social relations bespeak the development of a delightful inner life, a spirit untouched and unspoiled by coarse associations but abounding in sympathy, understanding and love.

From a psychologic point of view, these two remarkable women afford illustrations with striking contrasts as to the manner in which the human mind may be conditioned by the training. Mrs. Macy believes that Laura Bridgman possessed a remarkably brilliant mind with critical faculties perhaps even superior to those of Helen Keller. But, however brilliant this mind may have been, it had little of the richness of Miss Keller's. Laura's education came to an end when she was 20, due to the fact that her teacher, Dr. Howe, married at this time. The steps in her education as conducted at the Perkins Institute were formulated from those used in the case of Julia Brace. She was first taught the name of common articles by pasting the names in raised letters on these articles. The second step was the association of the word with the article; then she formed her words from separate letters, and finally learned the alphabet.

In all of her training it was necessary to hold her back, because she was most diligent and intent on her study. Through her entire life she made use of but fifty or sixty special vocal sounds. All of these were monosyllabic and seemed to have been spoken as if by accident. Nevertheless, it is believed that she might have been taught to vocalize. She was thought to be eccentric but not defective. She seemed to lack certain data of thought, but not in any marked way, while

her power to use what data she had was exceptional. Concerning the condition of her mind, Dr. Hall, who studied her carefully, found no reason to believe that she remembered anything previous to her childhood illness.

Although it is impossible to express in measurable terms the result of Laura Bridgman's sensory tests as, for example, in the case of Helen Keller, the several sensory components were carefully studied by Dr. Hall, and his summaries in this regard furnish a basis for this comparison.

The Sense of Smell.—The olfactory sense was always defective. It contributed little to her development. In the early years of her life it is doubtful whether she had any true olfactory perception, and she never had a habit of holding articles to her nostrils. At 49 years of age, when she was tested, she did like to smell flowers, a few of which she could distinguish. Sometimes she was able to recognize cologne. She was also able to identify ammonia, but in this case it is questionable whether the identification was due to olfactory stimulation. The responses may have been dependent on the irritating effects of the ammonia. She sometimes recognized and distinguished tobacco and onions, but only when the odor from them was quite strong. Apparently there was no difference between the olfactory perception of the two nostrils.

It is at once apparent, in comparing the olfactory sense of Helen Keller and Laura Bridgman, that a great disparity exists between them. The sense of smell was much less developed in Laura Bridgman than in Helen Keller, who has distinguished it among her senses as her "landscape" or "background."

The Sense of Sight.—After her eighth year Laura Bridgman was totally blind, and such vision in her right eye as she did retain from her second year until this time was of little service to her. The contributions to the sensorium in both cases, therefore, were on a par, and vision as such did not contribute more to Laura Bridgman than it did to Helen Keller. It should not be overlooked that in one particular the two cases present a marked and perhaps far-reaching difference in the organization of vision. Laura Bridgman retained her eyes until the end of her life. Miss Keller has for many years been entirely deprived of her retinas. In this detail alone, the structural conditions in the sensory organizations of these two women differed. It may be that the wonderful sense of direction possessed by Miss Bridgman can be attributed to the fact that she retained her retinas, although they were devoid of visual function. Miss Keller's total lack of the sense of direction may in this sense be ascribed to the fact that she does not posses retinas. LeMoine compared the surprising sense of direction in Laura with that of migrating fish, and also of the bat. He thought that there must be a sixth sense, the reactions of which take place at the surface of the body.

The Sense of Taste.—The gustatory sense was much impaired. Miss Bridgman was less sensitive to bitter and acid, and most sensitive to salt and sweets.

The Sense of Hearing.—The tests for hearing indicate a complete loss of audition in both ears. Laura was tested by heavy tuning forks with the stems placed between her teeth. Heavy tuning forks were used with Helmholz resonators. Pasteboard trumpets were fitted to her ears, and electric stimulation was applied to various parts of the external ear, but to no avail. On one occasion she said she thought she heard something like singing or talking. Generally her only feeling was one of vibration or jar. Her perception and conception of vibration seemed so close to ordinary auditory consciousness that a close relationship is suggested between these two elements of sensation.

The Sense of Touch.—Compared with Weber's table, experiments on Laura Bridgman seemed to indicate that her tactile sense was two or three times as great as that in an ordinary person, but in these tests she showed great variations. Dr. Hall was of the opinion that the acuteness of the sense of touch was centrally conditioned, due to her unusual energy of concentration. Spots were found indicating partial dermal anesthesia. Sometimes she claimed to be sensitive to an imperceptible particle of dust, but repeated tests seemed to indicate that this was probably imaginary. In general, she had developed tactile sensation to such an extent that she could estimate the age of visitors by feeling the wrinkles about the eye; she could tell the frame of mind by touching the face; she could also detect the degree of intelligence by the tonicity of the muscles or movements of the hands. From a characteristically flabby hand, she almost immediately recognized idiocy. All of the last mentioned sensory abilities belong to the group of stereognostic elaboration. They indicate how closely in parallel with Helen Keller Laura Bridgman had developed this sensory capacity. Dr. Hall found that the two compass points showed Laura's discrimination to be two or three times better than that of the person who can see.

My interpretation of this difference between Laura Bridgman and Helen Keller has already been given, as well as my opinion as to the value of such a generalized comparison in the analysis of sensation.

Laura's facial sense was not well developed, yet her hands and face seemed to be the most sensitive parts of her body. It was supposed that she could recognize the approach of another person by the undulations of the air on her face.

The Temperature Sense.—Miss Bridgman was not remarkably sensitive to temperature.

The Vibratory Sense.—Miss Bridgman was extremely responsive to vibration. She often spoke of herself as hearing through her feet. In this particular she resembles Miss Keller, who "listens" to the radio

with her hands and hears the sounds about the house through her feet. In this way she also distinguished step and voice. From rough preliminary experiments, it would seem as though Laura had been able to distinguish a musical interval of less than one octave by touch through her right index finger. She was conscious of vibrations in her throat when she made vocal noises. From these facts it was thought that the physiologic basis of her vibratory sense might have had some characteristics of a distinct sense. On the other hand, so far as may be judged from such tests as were applied to this element of sensation, Miss Bridgman did not seem different in any way from Miss Keller. It is, of course, unfortunate that metrical records do not exist in this respect, although there is nothing in the reports of Dr. Hall which warrants the belief that Laura Bridgman had any superiority in the organization of her primary pathways for vibratory sense.

The Motion and Position Sense.—The meager records of the motion and position sense leave some doubt as to the exact fundamental organization in Miss Bridgman's postural and motion sense. Judged by her general capabilities and her skilled acts, it would seem fair to presume that these components were normally developed.

The Balance Sense.—In this regard, Miss Bridgman was most sensitive. She did not have ataxia of any kind. She reacted quickly to rotation which made her dizzy and produced nausea. Her semicircular canals and their nerves were said to be in good condition. She was extremely sensitive to disturbance in equilibrium, and labyrinthine impressions appeared to be normally acute.

Sensitiveness to heat, to pressure and to electric stimulation were all below the average. As to her visceral sensation, according to Dr. Hall, she never developed heart or liver consciousness.

COMPARISON OF HELEN KELLER AND LAURA BRIDGMAN

If the lives of these two remarkable women could be considered in parallel columns, certain contrasts would be evident at a glance. There would be no doubt that Miss Keller has led a fuller life, one characterized by a greater variety of interests, more extensive contacts, greater depth of mental content and more impressive influence on her time. Laura Bridgman's limitations were largely those of circumstance. While she was not the first person of her kind to be subjected to training for the deaf and blind, much of her instruction depended on improvised innovations, and the experiments in her education were often too narrowly conceived. That she had a splendid mind seems clear. Her more or less secluded existence and limited mode of expression made it impossible for her to impress herself on a large circle of friends and acquaintances. She is known for the example she set rather than for

the immediate influence which she had on her day. Quite the reverse is true of Miss Keller. She has lived a more normal life in constant intimate contact with her environment, exerting her influence on all those around her and radiating a cheery and wholesome spirit throughout the household of which she is the beloved center. She has made many friendships with important and interesting persons of her day. None of these is more touching in its remarkable understandings than that with Mark Twain. Mr. Clemens' regard for Helen Keller is expressed in many letters and in some of his writings. He appreciated her intellect, her lovable disposition, her rare social gifts. He was impressed above all by her marvelous achievements, especially that information and insight concerning the world around her by which she has learned to express herself so forcibly in spite of almost insuperable handicaps. Joseph Jefferson was another who delighted in a charming friendship with Miss Keller. In their numerous visits together, the great comedian would often play for her certain scenes of his famous comedies. She followed his acting merely by touching him, and appreciated his whimsical humor in a way that was perhaps denied to many of his more formal audiences.

Dr. Alexander Graham Bell also enjoyed the privileges of Miss Keller's intimate friendship. She numbers among her friends many authors, distinguished publishers, men of science and artists, with whom she carries on an interesting correspondence. But it is not through her capacity for friendship alone that she spreads her influence. She has done much thinking, and from her great fund of reading is able to draw most interesting and telling comparisons between the present times and the past. She has strong opinions which her special gifts and education enable her to express most effectually. Her views concerning policies and events, personalities and political topics are always interesting. It is not necessary to dwell here on her literary style or on her mastery of literature. An example of this has already been given in her letter to me concerning the significance of olfactory sense. She has decided religious convictions and a philosophy of life which have grown out of her long meditations. One feature concerning this philosophy is the almost complete displacement of physical fear, particularly the fear of death. Miss Keller is quite stoical in these respects. I have been surprised to see the equanimity with which she bore the suffering incident to a fall in which she seriously injured her knee. I have also noted previously the fact that painful stimuli seemed to cause her less distress than is felt by the normal average adult. Perhaps Miss Keller is different from other persons in her lack of fear concerning disease and death, because she firmly believes that with the passing of this life she will enter another in which all of those senses whose privileges she

has here been denied will be restored to her in full, and she will then be able to hear, and to see, and to extol the glories of a new world thus revealed to her.

The differences between Miss Keller and Miss Bridgman seem to be in direct proportion to the methods of training, and to their teaching. The principles of education underlying the training of these two women were decisively different. Dr. Howe surrounded Laura Bridgman with restricted regulations and puritanic limitations. These resulted in her exclusion from many contacts with life which would have liberalized her attitude and amplified her reactions. Her religious beliefs consisted largely of the rigorous tenets derived from early pioneer days. Her understanding of life was conditioned by a thoroughgoing puritanism. Her teacher, Dr. Howe, was responsible for all of this, and doubtless himself believed that all of his pedagogic methods had a righteous as well as a wise foundation.

The fact that Laura's life was less full than Helen's must in large measure be attributed to the fact that her education ceased when she was 20 years of age, and that her discipline depended on fixed times and set exercises. The method of Mrs. Macy in developing Helen Keller was totally different. From the very beginning of her instruction this ingenious teacher has arranged every experience so that it might have real pedagogic value, whether in play, in work or in rest, as well as in all other social activities. Helen Keller has been taught to capitalize every opportunity for learning from each impression entering her sensorium. This began when she was 7 years old and continues to the present day. The mind which started to unfold in childhood under the wise guidance of an exceptional teacher has continued its progressive expansion with each succeeding year. There are those who believe that Mrs. Macy operates in some occult way on Helen Keller's mind and that many of her achievements are due to some mysterious influence or suggestion exercised by the teacher over the pupil. This, in the main, is pure fiction. The relation which exists between them is that of mother and daughter. But the daughter has decided notions of her own, which even filial devotion frequently will not restrain. Their religious outlook, for example, is totally different. Where they are at one, however, is their mutual belief and implicit confidence in the methods of training and education which have made Helen Keller's mind what it is.

In the ultimate adjustments to life of Laura Bridgman and of Helen Keller, there are also certain striking differences, differences, however, which seem to be directly attributable to educational opportunity. In this respect there can be no doubt that Helen Keller has been most highly—indeed, exceptionally—favored. Both women manifested a definite degree of dependence. They needed the assistance of others to make amends for the lack of sight and hearing. For example, they

could not go about freely and safely in the midst of the congested conditions of ordinary life. Many of their contacts required an intermediary for their proper interpretation, and yet within certain limits their adjustments to life were so made that they were not unduly dependent. Their compensatory reactions in many respects counterbalanced their dependence.

In their independent achievements Helen Keller deserves, as might be expected, a much higher rating than Laura Bridgman. Not only are her social qualifications of a much higher order, but she has achieved distinction as an authoress, as a lecturer and as a thinker.

Laura Bridgman's accomplishments were of a far simpler order. They were outstanding in her day as representing the first notable instance of this kind. Helen Keller has developed a mode of speech and vocal expression which Laura Bridgman never acquired. Miss Keller is capable of conversing, and her conversation, although lacking in inflection, is thoroughly intelligible. At the most, Laura Bridgman was capable of fifty or sixty vocal sounds, few of which were recognizable words in any language although they all had definite connotation understood by her intimates.

Miss Keller is able to carry on conversation by listening to the speech of another. In doing so, she applies her fingers to the larynx, lips and nose. Laura Bridgman never possessed this accomplishment. Both of them, however, developed a high degree of manual dexterity; both were able to read with the fingers; both were able to write, and both were able to sew. In the latter respect Miss Bridgman excelled Miss Keller, who, however, has learned to use the typewriter with proficiency. If there is any difference in manual dexterity between them, it slightly favors Helen Keller.

THE DEVELOPMENT AND UTILIZATION OF THE SENSES

Only a brief comparative summary of the degree to which the several senses were developed and utilized is necessary to indicate the striking similarity between these two women.

In the sense of smell, Helen Keller had a supreme advantage. Laura Bridgman was almost wholly defective in this regard. The postmortem examination of her nasal cavity showed that she had suffered from a severe inflammation of the nasopharynx, after which she was totally devoid of the sense of smell for eight years. The nasal mucosa was generally diseased. She had a severe nasal catarrh which lasted all her life. The ethmoid bone and the mucous membrane covering it were seriously diseased in consequence of the inflammation. This was most particularly so on the left side. After her fifteenth year, she had slight olfactory perception.

Both of the women were blind. Helen Keller possesses no retinas and probably has no visual images. The latter fact together with her pronounced lack of sense of direction are to be made the subject of further studies. Laura Bridgman was totally blind most of her life. She had some degree of visual imagery and up to her eighth year had a feeble light perception in one eye. She possessed a most remarkable sense of direction. In this connection, it should be noted that in Laura Bridgman neither eye was removed and she retained both retinas, which, however, were insensitive to visual impressions throughout most of her life. Both upper eyelids were sunken. There was a distinct lack in the amount of orbital fatty tissue. Both eyeballs were small and indicated the presence of a prolonged severe inflammation. The right eye, about one-half the normal size, was wholly enclosed by the sclerotic coat except for a small central area 2 mm. in diameter, in which the cornea was represented by less opaque tissue. The left eyeball was larger than the right. The cornea was altered and opaque and consisted of a small area, 4 mm. in the horizontal and 2 mm. in the vertical. The eyelids were always closed. In a test of the sensitiveness of the eyes, light directed from a heliostat did not produce light perception but caused pain when concentrated. No effect was produced by gentle pressure or electric stimulation of the eyeballs.

The sense of taste in Miss Keller is little impaired, while that in Miss Bridgman was generally defective.

The sense of hearing was totally absent as such, both in Miss Keller and in Miss Bridgman. The pathologic report of Miss Bridgman's ears shows that the tympanic membrane was almost entirely destroyed and that the malleus and incus had entirely disappeared.

Laura seems to have had a certain superiority, particularly in two-point touch, although I have questioned this advantage over Helen Keller in the technical discussion of it earlier in the paper.

In temperature sense, pressure sense and electricity sense, Laura Bridgman was said to be below the average, while in these respects Helen Keller corresponded quite accurately with the normal.

In the vibratory sense both developed acute sensory powers, but there is certainly nothing to indicate any special development of the receptive ability in either of them. Such was certainly not the case in Helen Keller, who corresponded closely to the normal. It was probably not true of Laura Bridgman.

The postural and motion sense in Helen Keller was about equivalent to that of the average normal adult, and judging from the history of Laura Bridgmen, the same was probably also the case with her.

The balance sense appears to have been well preserved and corresponds closely with the normal in both.

In comparison with normal adults, Helen Keller and Laura Bridgman both illustrate the same points, namely, that the peripheral receptors of

the general sensory apparatus do not exhibit any compensatory development in those deprived in infancy of the special senses of sight and hearing. The fundamental organization of those senses which remained intact in Laura Bridgman and Helen Keller has no advantages over that of the normal adult. The primary sensory mechanisms were no more efficient than in the average, yet if ratings of comparative intelligence were made of Laura Bridgman and Helen Keller with the average run of mankind, it is unquestionably true that these two women would stand much higher in the scale than this average. If such an average were taken of any general community of civilized society including all walks of life, both educated and uneducated (but not defectives), there can be little doubt that both of these women would stand high in the figures of this average. If they were compared to those who have benefited by education, through high school grades, Laura Bridgman might in certain respects show intellectual inferiorities, but her advantages in other regards would probably offset this.

Helen Keller would stand, of course, far above such a rating. In fact, if she were compared with those who have enjoyed a full college education, there is no question that her rating would far surpass the average of those trained in this way. Indeed, it is my opinion that there are few intellectual men and women living today who could develop a higher intelligence quotient than Helen Keller, with properly adjusted tests. There are many features in her intellectual development which might justify her inclusion in the class of genius.

The comparative efficiency of these two women clearly indicates that they stand well above the rank and file of the human race. This fact is important since Laura Bridgman and Helen Keller are largely dependent on a single sensory area of the brain for their intellectual rating. This area is the parietal lobe which administers the functions of general body sense as typified by the sense of touch. All other sensory areas in the brain, except those for the sense of smell and taste as specified, are inactive. It thus seems justifiable to infer that the parietal area for general body sensation must have reached a high degree of development in these two special cases. Laura Bridgman and Helen Keller, with a small portion of their brains in active commission, have made an intellectual and social adjustment to life which, at the very least, is equal to the average. This must mean that the average brain with all of its parts working develops only a small fraction of its potential power. Such a conclusion is important in the light of the known amplifications of association which take place in the frontal lobe when all of the senses are contributing their complements of sensory synthesis to the mental life of the person. My figures as applied to the case of Laura Bridgman would seem to show that only about 25 per cent of the brain's actual power is developed by the average of the race. This

fraction is in the broadest sense a working estimate only. Whatever the exact fraction is, this much may be said: If for the present it is a matter of reproach, it may for the future be a sign of promise.

Sir Arthur Keith believes that mankind has as yet developed scarcely more than one half of its possible brain power. Critical observation and study of the race as a whole must justify the general correctness of this low estimate. The facts here presented seem to indicate that man already has the mechanisms for a more adequate adjustment to life. He does not need any additions to his present equipment except the determination to develop its capacity by his own unaided efforts. The social and intellectual distinctions existing among men depend not on differences in the fundamental pathways of the senses, but on the ability which the brain acquires to elaborate the impressions received by these pathways. It is the associational expansions within the brain which account for the degree of its power. In explanation of Miss Keller, Miss Bridgman and others with similar cases, it may be urged that their achievements are the result of compensation, and that unless an imperative demand for such compensation exists, no such expansion ever occurs. Many organic structures are endowed with compensatory capacities which develop under the stress of need. That need may be a sudden emergency, a sudden privation, or it may be a slow and persistent demand calling on the latent powers of a structure which would otherwise remain below its highest efficiency. This is true of the muscular system in athletes. It is also true of the excretory system in certain kinds of poisoning, or of the cardiovascular system and the respiratory system in many diseases. It is equally true of the brain as attested by facts pertaining to specialization and intellectual training.

To maintain that expansion in the powers of this organ apparent in the special cases here discussed is compensatory affirms that the brain is capable of further development. It is not necessary to rely solely on theory to uphold this postulate. The brain of Laura Bridgman is available for tests of its validity. This brain was carefully studied by Dr. Henry H. Donaldson and supplies many important facts bearing on the problem in question. Laura Bridgman's brain was removed eight hours after death. Its volume was calculated by Dr. Donaldson as 1,178 cc. and its weight, 1,204 Gm. All of the cranial nerves were identified except the spinal accessory nerve. The brain stem, including the medulla, pons and cerebellum, was normal. The superior and inferior colliculi were flattened and small, as was also the pulvinar. All were much smaller than in the normal brain. These structures illustrate clearly the organic response to functional demand. Being blind and deaf, Miss Bridgman made no demand on the primary receiving centers of the functions of sight and hearing. In consequence, they showed little of their normal and proper development. The cerebral hemispheres also revealed developmental failures of the same general

character. The defects here were conspicuous in those areas of the brain on which little functional demand was made. Thus, the occipital lobes were small and flattened, apparently in direct proportion to their lack of function in visual capacity. The temporal lobes were also small, and all of the fissures in them were wide, indicating a low degree of convolutional development. This smallness and imperfect growth are significant in connection with the fact that Miss Bridgman was deaf. The insula (island of Reil) was much more exposed than in the normal brain, being more exposed on the left than on the right side. Its exposed area on the left was 128 square mm., and on the right, 40 square mm., a proportion of 3 : 1. In the normal brain the island of Reil is entirely concealed. Broca's area shows some defect which is significant, since Laura Bridgman was right-handed. The cuneus of the occipital lobe was small on both sides, but the left was smaller than the right. This deficiency has a peculiar significance in view of the fact that Laura Bridgman had light perception in the left eye until she was 8 years old.

TABLE 11.—*Comparison of Frontal Lobes of Laura Bridgman, an Insane Person and a Normal Adult*

	Right, per Cent	Left, per Cent	Total Average, per Cent
Laura Bridgman	36.8	39.9	38.3
Insane woman	40.0	41.0	39.5
Normal adult	38.3	40.9	39.6

The parietal lobe was well developed, in response to touch sensation, particularly for the hand and face.

Measurements of the surface of the frontal lobe show that in this region Laura Bridgman was somewhat below the average. Table 11, a comparison made between Miss Bridgman, an insane woman and a normal adult, shows the relation of the right and the left frontal lobes to the entire surface of the brain, in percentages.

The difference appears to be due to the smaller average in the depth of the sulci in the frontal lobe.

The total area of Laura Bridgman's cortical surface was as follows: right, 98,946.5 sq. mm.; left, 101,256 sq. mm.; total, 200,202.5 sq. mm. This is somewhat below that of the average normal woman.

In the matter of cortical thickness, the Bridgman brain showed certain departures from the normal. The average normal thickness of the cortex varies from 2.24 to 2.91 mm. The average of nine normal brains (all areas) was 2.92 mm. The average of Laura Bridgman's brain (all areas) was 2.59 mm. Not only in its thickness but also in its cell richness the cortex of the Bridgman brain showed differences as compared with the normal. In general, the large cortical cells were smaller and fewer in number than in normal brains. Laura Bridgman's brain

showed cellular defects in the visual, olfactory and taste areas. Her cortex was 89 per cent as thick as the normal.

The sensory area for general body sense was normal. The speech cortex was not particularly thin. The speech area neurons, although somewhat small, did not show remarkable departures from the normal. Perhaps the fact that the speech area (Broca's area) in Laura Bridgman was so nearly intact in a dumb person may seem surprising. Laura Bridgman made use of fifty or sixty different sounds. The only words she ever used intelligently were "doctor," "see" and "ship." But there are many indications that she followed gestures made with her hands by movements of her lips and tongue, so that the relation between the gesturing motor centers for the limbs and the gesturing motor centers for the lips, tongue and organs of speech generally is probably most intimate. This, in some sense at least, would explain why Laura Bridgman's speech area appeared to be so nearly intact.

Expansions of the brain in response to functional demand would seem to depend on some definite physical basis. It is probable that such expansions are not due in any great measure to a material increase in the cortical cells. The number of these cells is already determined in the late fetal stages. The further development of the brain depends rather on connections established between various nerve cells by means of nerve fibers. Many facts indicate that such connections are made only when called for by needed communications. One structural result of this functional call is the appearance of an insulating substance on the nerve fibers. This insulation provides a greater efficiency in the fibers as conductors of nerve impulses. The acquisition of this insulating substance is known as maturing, and the insulation itself is called myelin. This is a fatty compound of complex nature. In his study of Laura Bridgman's brain, Donaldson expressed the opinion that expansion of this organ during life is due to increased medullation, that is, increased deposit of myelin on the nerve fibers. If this is the case, and there are many reasons to believe that it is, the chief factor favoring the deposit of myelin seems to be the functional use of the several brain areas. When nerve fibers are continuously called on to convey impulses, they tend to acquire their insulating sheaths, that is, to become myelinized.

The degree of insulation in relation to the functional capacity of nerve conduction may be determined in several ways. It is possible to estimate the amount of myelin in the insulating sheaths and nerve fibers in the brain at different periods of mental development from infancy to maturity.

In the infant at birth the percentage of myelin in the brain is 35.75; at 8 days of age, 38.5; at 6 months, 43.9; at 2 years, 45; at 3 years, 48.7; at 36 years, 50.9, and at 68 years, 52.3.

These estimations show a progressive increase in the amount of myelin in the brain, which seems in direct proportion to the increase of mental powers. In new-born cats and dogs little if any myelin is present in the optic nerve, and as the eyes remain closed for a week or ten days, there is at that time no visual function in these lower mammals. The human fetus at seven months has hardly any myelin in the optic nerve, but an infant born prematurely at this time rapidly myelinizes this nerve. These facts indicate that myelin insulation is in direct proportion to functional demand. In this connection I will add certain observations from studies which I have made with Casamajor on the relation of myelinization to the development of behavior in animals. By this study, we were able to show that special tracts in the brain myelinize as special behavioral components make their appearance, at the different stages from birth to adult life. Different animals show a different degree of myelinization according to their functional capacity at birth. In the rat, there is no myelin in the brain. The animal is born, as it were, prematurely and almost its entire care depends on the mother. It does not nurse until the eighteenth hour after birth. The dog and the cat are both capable of approaching the mother, and have certain other behavioral components immediately after birth. In their nervous system, myelinization is meager at this time. The guinea-pig is born in an almost complete functional state. It sheds its milk teeth in utero, and on the second day forages for itself. Its entire brain shows almost complete myelinization at birth.

Such facts as these strongly suggest that the relation of myelinization to development of the brain is based on the functional demand for specific conduction. It is probable that the degree of myelin in the human brain varies greatly in different persons. In certain diseases and in feeblemindedness, it is distinctly low. On the other hand, the greatest brain efficiency seems to depend on the ultimate myelinization of the greatest number of association fibers within the brain.

The cases of Laura Bridgman and Helen Keller illustrate how a specific area of the brain may be expanded to make amends for deficiencies in many other areas. It is unfortunate that the myelin contained in the parietal lobe of Laura Bridgman's brain was not estimated, but this is a consideration which must be left for similar studies in the future.

It is, I believe, the concentrated and systematic application of attention which endows experience with its full richness in associational value. Such attention of course depends on continuous functional use of association fibers in the brain. Time and patience are necessary for the development of such attention. Forel has likened consciousness to a retina in which there is a floating macula of attention. The difficulty with most of us is that this macula of attention floats too widely and

too much, with the consequence that insufficient time is allowed for the needed concentration on any object or situation. As a result, there is an actual dearth of associations connected with most of the factors in our experience. Judgment and reason and all of the higher faculties suffer in consequence because the associational surplus from which they may draw their higher development is extremely meager.

The case of Helen Keller demonstrates what a brain may do under the influence of concentrated, systematic attention. It shows the expansions in understanding and in knowledge which result when the brain is properly importuned to develop them. As she maintains, the principle of Helen Keller's development has been Practice! Practice! Practice! The question naturally arises whether this principle applies to any brain, and in particular to the brain of modern man. The answer apparently should be in the affirmative. There are relatively few brains which could not be made better and more efficient by pursuing the proper methods of development. Certain difficulties have arisen heretofore and still do arise as obstacles. They are not, however, in the brain's potential power to respond, but rather in the general lack of desire to make the necessary demands for such further development. Many observers are intensely pessimistic and doubt that the ascendant elements in the human race today will in this regard ever develop to a higher degree. Indeed, there are some reasons to believe that mentally the human race as a whole is retrograding. If one views modern man in the broad sense as all that part of the race which has existed during the historic period, it would seem in some respects that our mental capacities are inferior to those of the Greeks, probably to those of the Romans, and it may even be to those of the Egyptians. So that concerning the historic period, if any statement seems justified at all, it is that mankind has stood still intellectually. The outright pessimist will say that it has gone backward. Nor is there now apparent any reassuring prospect that the essential physiologic process (application, patience, practice) on which further development of the brain depends will have its full opportunity. The day in which we live is characterized by a predominant spirit of haste. Most of our ideals are shot through by aspirations for speed. In consequence, insufficient time is allowed for that patience, that concentration and that systematic practice which are the prerequisites of further brain development. We find ourselves in the midst of many and multiplying distractions. The rapid influx of new contrivances deceives us into believing that we are developing new ideas. With the exception of many luxuries and labor saving devices, we lead about the same lives as did men 300,000 years ago. Human behavior and human relations are changed but little, certainly not enough to preclude those ancient repetitious cycles of maladjustment which have led from one war to the next, from one revolution to another, which have frustrated our best civic

intentions and efforts and which have left us little, if any, better off morally or intellectually than our predecessors in the early days of human history.

Yet, brain development, like all other development, follows the laws of evolution. Into this evolutionary process during the past half century, there has come a new element. This factor has not operated heretofore, and the presence of it as a decisive influence may have far-reaching consequences. Intelligent men and women have come to recognize that there is such a thing as evolution. Being conscious of this fact they may, and undoubtedly will, direct their attention increasingly to its processes and to the nature of its underlying causes. What discoveries will be brought to light as a result of such efforts cannot be predicated. Much may properly be expected of it both to increase the understanding of our own mechanisms and to improve their capacities.

Another encouraging influence is found in the developmental history of man's brain. From my studies of the prehistoric human brain I was led to conclude that, beginning perhaps a million years ago with the ape-man (Pithecanthropus) and coming to modern man, the brain has shown a steady progressive development. Thus there is reason to believe that the brain of man today represents some intermediate stage in the ultimate development of this master organ of life. As a race, we appear to have developed but a fraction of its power. The greatest problem before us, therefore, is how to make a still better use of the brain. This problem may be solved only by the development of that comprehensive science which will eventually supply an adequate knowledge of all the mechanisms underlying the control of human behavior.

ABSTRACT OF DISCUSSION

Dr. S. E. JELLIFFE, New York: Dr. Tilney said, and showed by a number of figures, that the tests of Helen Keller and the average normal, as he called it, were about the same. I seriously doubt that the quality of the tests or the nature of the tests that have thus far been devised are of any particular value. I am emboldened to make this statement more or less when I commence to consider some of the studies in eidetics made by Jaensch of Marburg, in which the value of the synesthesiae that Dr. Tilney has already made reference to are brought out. Helen Keller showed remarkable values in associating—I do not recall the details of her associations, but the associations between smell and sight and color and form and shape and feeling, etc., are really astounding. The students of eidetic phenomena have developed just this type of testing, and it is an extremely interesting corroboration of what Dr. Tilney has pointed out, namely, the persistence or the capacity for further elaboration of the olfactory eidetic phenomena in this particular patient who has been so carefully studied. And what is true of olfactory eidetic phenomena—eidetic meaning "image"—is true, as shown amply, for other types of sensory areas. Through this particular method of investigation, elaborated by Jaensch, it seems to me we have a far greater discriminative type of testing than those which we as objective neurologists have as yet devised.

ENCEPHALITIS PERIAXIALIS DIFFUSA*

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Encephalitis periaxialis diffusa was described by Schilder [1] in 1912. Quite independently, Marie and Foix [2] published an account of a similar case in 1914. Since then clinicopathologic studies of approximately forty additional cases have been reported. In spite of the growing literature concerning this condition, most of the cases have not been recognized clinically. This seems justifiable in the more acute, fulminating cases, and in those in which unilateral focal signs predominate, with or without evidence of increased intracranial tension. If opportunity is afforded for observation and study of the more chronic types of cases presenting general and bilateral signs of loss of cerebral functions, a correct diagnosis should generally be made.

Within a comparatively short time two cases presenting widely divergent clinical pictures have been studied at the Mayo Clinic. To point out some of the diagnostic difficulties which may be encountered and to emphasize the necessity of considering this condition in a differential way these cases are reported.

REPORT OF CASES

CASE 1.—A boy, aged 7, was admitted to the clinic on June 6, 1926. The father stated that the child had never been robust, and that at 1 year and at 2 years of age he had had convulsions, which were attributed to overeating. At the age of 3 he had had chickenpox, and at 4 he had suffered from a severe attack of measles, which was complicated by bilateral suppurative otitis media. The left ear drained for sixteen months; the right ear was still draining at the time of admission. Ten weeks previously the parents had observed that the child was growing deaf and becoming somewhat apathetic. Six weeks previously it had been noted that his eyes no longer converged and that he stumbled and seemed clumsy. While playing beside his father three days before admission he fell to the floor on the left side. He rose only to fall again in a similar manner. The legs

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1. Schilder, Paul: Zur Kenntnis der sogenannten diffusen Sklerose (über Encephalitis periaxialis diffusa), Ztschr. f. d. ges. Neurol. u. Psychiat. **10**:1, 1912.

2. Marie, Pierre, and Foix, Charles: Sclérose intra-cérébrale controlobaire et symétrique, Rev. neurol. **1**:1, 1914.

began to twitch and the arms and face were successively involved, while the eyes turned upward and to the left. Still conscious, the boy was carried to a physician's office where the spasms were checked by ether. On regaining consciousness after the anesthetic he was blind and complained of frontal headache, which persisted for twelve hours. The following day, at 2 p. m., he had another convulsive attack and in the ensuing twelve or fifteen hours he vomited about twelve times. The vision and general condition then improved rapidly.

Examination.—The child was pale, and moderately well developed and nourished. The systolic blood pressure was 108 and the diastolic 54. The pulse rate and temperature were normal throughout his visit. At times he was apparently able to hear a moderately loud conversational voice, but he failed to understand much of what was said to him. He talked well for a child of his age. The left drum head was scarred, and the right ear showed evidence of chronic suppurative otitis media. Bárány's caloric test evoked normal responses. The child read moderately large print. Perimetric or even satisfactory rough visual fields could not be plotted. Fundoscopic examination gave negative results. Neurologic examination showed slight vertical nystagmus when the patient looked to the left. There was no convergence. The pupils were dilated and reacted to light and in accommodation. There was a suggestion of partial paralysis of the lower portion of the right half of the face with associated movements of the fingers and toes of the left side. The right patellar and achilles reflexes were somewhat exaggerated, and Babinski's sign was present bilaterally. The abdominal reflexes were not obtained. Vibratory sensation was lost over both malleoli only; joint sense was undisturbed. On the finger-to-nose and heel-to-knee maneuvers there was incoordination, particularly on the left side. The gait was somewhat ataxic and slightly spastic.

Lumbar puncture revealed clear colorless fluid under 50 mm. pressure; there was prompt response to jugular pressure. The Wassermann reaction was negative, the Nonne reaction positive, and there were three small lymphocytes for each cubic millimeter. The benzoin curve was 000001333310000. Urinalysis, blood counts, the Wassermann reaction of the blood, the urea content of the blood and stereoscopic roentgenograms of the head and chest gave negative results. Roentgenograms of the area of the left mastoid were normal; those of the right showed moderate cloudiness. The suppurative otitis media on the right side cleared up under treatment, and the patient gained 5 pounds (2.3 Kg.).

Course.—The patient returned home on July 2. There was no obvious change until July 12 when he vomited several times on arising, complained of severe headache and wept for fear of dying. Three hours later he had a slight general convulsion which began in both hands, was associated with sudden loss of consciousness and lasted two or three minutes. He was stupid and confused afterward and occasionally cried out as if in pain. He refused food and vomited every fifteen or twenty minutes. Early in the afternoon while he was lying on the right side the left hand twitched, and a general convulsion ensued. Following a second and more severe convulsion twenty minutes later, he became comatose. In the succeeding three hours similar attacks occurred at short intervals. At 6 p. m. he was taken to the hospital. He appeared dull and exhausted, and tossed about restlessly. He soon became noisy and violently resistive, thinking he was being poisoned. Consciousness was partly regained the following morning; he was blind. During the day he became more rational and vision improved. By July 15, he could follow a figure about the room.

On July 16, the patient was brought back to the clinic. He was then much more emotional than during his previous visit and often perseverated in speech. He

was unable to hear with either ear. The eyes diverged at an angle of about 10 degrees. He was able to read only the largest print. The eyegrounds were normal. Visual fields could not be accurately plotted.

Additional Neurologic Data.—There were a few strokes of ankle clonus on the left side and exaggeration of the spastic element of the gait. On July 29, the patient's condition was about the same except that the pupillary responses were definitely slower than before. A ventriculogram, made on July 30, was normal; it was noted that the cortex was edematous and that the subcortical cerebral substance was resistant to the passage of the cannula. The patient recovered satisfactorily and was walking about on the third day. He had become more irritable and exacting, however, and was extremely deaf and relatively blind. During the night of August 7, he had a generalized convulsion.

Diagnosis.—At first the pathologic process was not suspected. The gradual evolution of the clinical picture with change in personality and loss of emotional control, deafness and impaired comprehension, diminished visual acuity, evidence of bilateral involvement of the pyramidal system, incoordination and sensory disturbances, the negative results of the examination of the cerebrospinal fluid, and the normal ventriculogram all served to suggest and finally affirm the possibility of Schilder's disease. On Aug. 11, 1926, a formal diagnosis of encephalitis periaxialis (Schilder) was made, and the patient was dismissed.

Later Course.—Later it was learned through correspondence with the father that the patient's condition grew steadily worse. Within a week after his departure he became totally blind and uncomprehending. By September 15, he was unable to walk. Control of arms and legs was gradually lost, and about October 10 he became unable to speak. Early in November, he had difficulty in chewing and in moving the tongue; subsequently dysphagia developed. He died at home on Nov. 26, 1926. Necropsy was performed by Dr. Oler, but nothing of general significance was found. The brain was sent to the clinic for study.

Macroscopic Appearance of the Brain.—The brain had been removed intact within the meninges. Removal of the dura did not reveal a gross lesion on the surface of the brain. After fixation, the midbrain was cut across, and the pons, medulla oblongata and cerebellum were removed from the cerebrum. The cerebrum was divided by longitudinal section through the corpus callosum, and the left hemisphere was then cut by coronal sections, 1.5 cm. apart; the right hemisphere was cut by horizontal sections, and the cerebellum at right angles to the direction of the pyramidal fibers. In the sections of the left hemisphere the white matter was of a grayish gelatinous appearance, most extensive in the occipital lobe. The gray matter was apparently normal, although the stria of Gennari was not visible. The arcuate fibers were normal in the lower half of the calcarine fissure but were involved in the upper half and in the gyri above this fissure. The medullary substance was much softer in consistence than the gray matter or the normal white substance. There were a few small cysts in this hemisphere; more anteriorly, there was diminution in the degenerated area, but more normal white tissue became visible so that at the level of the splenium of the corpus callosum about two-fifths appeared normal. At the level of the posterior end of the lenticular nucleus, the upper two-thirds was normal. At the level of the tip of the temporal lobe the degeneration had entirely disappeared. The entire frontal lobe was apparently normal. The anterior edge of the lesion was not sharply demarcated, but anterior to where the main process had advanced there were many smaller areas which varied greatly in size; some were fairly large and others were minute, and again there appeared places where they were coalescing. At one place they seemed to

have advanced along the capsula externa, leaving the myelin of the association fibers of the insula intact, and involving the white matter above the insula. At one other place a large isolated area was seen above the corpus callosum where it begins to spread out into the corona radiata and lateral to the gyrus callosus. The right hemisphere showed similar degeneration. Sections through the upper portion appeared to be normal, but sections at a lower level showed a change of the medullary substance with preservation of the arcuate fibers and in the posterior part of the hemisphere even these were absent in some areas. The lesion was more extensive than on the left, especially in the lower half, as the entire temporal lobe was involved so that more than half of the right hemisphere showed degeneration. The cysts that were present were larger but less numerous than on the left. Gross change was not noted in the midbrain, but in the pons there was a patchy distribution of the lesions, which was not quite symmetrical. The nuclei in the roof of the fourth ventricle and the fibers in the cerebellum were normal. In the medulla oblongata and the upper cervical cord the only change was a slight gelatinous appearance of the pyramidal tracts, and this was noted only on close examination. The optic tracts seemed to be partly normal on both sides, but the upper portion was of a gelatinous appearance, particularly in the distal half; the optic nerves were slightly shrunken but not to a marked degree.

CASE 2.—A woman, aged 27, was admitted to the clinic on June 29, 1927, complaining of blindness. She had always been well and strong. Six and a half weeks previously she had been delivered of her first child by forceps. Two days later, a foul vaginal discharge was noted, and fever and malaise set in and persisted for three weeks. Four weeks before admission the patient had noticed slight blurring of vision which progressed to complete blindness in the course of a week. Subsequently, her general condition improved considerably.

Examination.—The patient was pale and slender. She was unable to distinguish light from darkness. The pupils were dilated and did not react to light or in convergence. The optic disks were pale and slightly edematous; the retinal arteries were somewhat contracted. The blood pressure was 116 systolic and 80 diastolic; the pulse rate and temperature were normal. Neurologic examination showed only a partial paralysis of the lower portion of the left half of the face.

Lumbar puncture revealed clear colorless fluid under pressure of 100 mm.; there was prompt response to jugular pressure. The Wassermann reaction was negative, the Nonne reaction was positive and there was one small lymphocyte for each cubic millimeter. The colloidal gold curve was 1110000000. Urinalysis, examinations of the blood (including a differential count on 200 cells and the Wassermann reaction) and stereoscopic roentgenograms of the head and chest gave negative results.

Course.—During the course of the next few days a marked change occurred. By July 2, the patient was slightly stuporous and complained of nausea. Examination showed a generalized tremor, exaggeration of the partial paralysis of the left side of the face, increased tendon reflexes on the left side and involuntary micturition and defecation. On July 4, the patient was stuporous, and she grimaced frequently as if in pain. In addition to the facial weakness, there was partial paralysis of the left side. Lumbar puncture yielded clear colorless fluid under pressure of 300 mm. On the following day there was complete paralysis of the left side, the pulse rate was 40 and the patient was in coma.

The ophthalmologist made a diagnosis of optic neuritis on his first visit. This was based on the history of puerperal sepsis, rapid loss of vision, absence of pupillary reflexes and the somewhat edematous optic disks with constricted retinal arteries. The rapid development of headache, nausea, vomiting, gen-

eralized tremor, hemiplegia, involuntary micturition and defecation, and coma all suggested focal complications. When to this was added the increase in pressure of the cerebrospinal fluid to 300 mm. with bradycardia of 40, exploration of the right frontoparietal area was advised on the assumption that an abscess of several weeks' duration might be found. It was realized that even such a process could hardly explain the loss of vision. Craniotomy, July 5, revealed soft degenerating material 3 cm. below the cortex. The patient died on July 9.

Postmortem Observations.—The brain was removed. No gross lesions were noted on the surface. Signs of increased intracranial pressure were not present, and the vessels around the base were free from gross lesions. The optic nerves were shrunken. After fixation the brain was cut by coronal sections. The right lateral ventricle was larger than the left, and the septum pellucidum was displaced to the left. Areas of softening were present throughout the hemispheres, more numerous on the right and absent from the midbrain, pons, cerebellum and medulla oblongata, all of which appeared to be normal. In the left hemisphere there was an area of softening, extending from the posterior third of the frontal lobe to the anterior end of the insula. This, like all the other areas of softening, involved only the white matter, leaving the cortical substance and the basal nuclei free from degeneration. The center of the area was softer than the periphery which was grayish and gelatinous, varying greatly in thickness. In some places it was only a few millimeters thick, while in others it was several centimeters. There was another large area of softening in the parieto-occipital region just underneath the cortex; this area extended back into the occipital lobe and its posterior portion was gelatinous in appearance and consistency. Another smaller area of softening around the calcarine fissure was of a spongy consistence. The stria of Gennari was, for the most part, preserved. These three areas were the only ones noted in the left side and were independent of each other.

In the right hemisphere the areas of softening were more numerous but not so large. In the frontal lobe there was an area involving the white matter underneath the inferior frontal convolution where the softening was not so apparent and was more gelatinous and spongy in appearance. In another area underneath the mid-frontal convolution degeneration was more apparent. More posteriorly and medial to the lower third of the precentral convolution there was a more extensive area of softening extending inward to the corpus callosum, downward to the middle of the claustrum and backward to the level of the splenium of the corpus callosum.

The anterior end was soft and spongy and somewhat cystic, while the posterior portions were gelatinous in appearance and not so soft. There was another large gelatinous area in the occipital pole, involving the white matter around the calcarine fissure. This area included the median two thirds of the occipital lobe leaving the outer third intact. The line of demarcation of most of these areas was distinct and sometimes sharp, but occasionally the margins faded gradually into the surrounding tissue and the exact termination could not be distinguished grossly. The areas of degeneration were of peculiar distribution and could not be accounted for on a vascular basis since they did not correspond to the blood supply of the hemispheres.

HISTOLOGIC METHODS OF STUDY

For the purpose of studying the extent and distribution of the lesions after fixation in formaldehyde sections were cut through each hemisphere and the hindbrain in case 1, and coronal sections through both hemispheres in case 2. These were mounted on glass plates in celloidin and were stained by the Weigert myelin sheath method for fiber tracts. By this procedure the distribution and extent of

the degenerative processes were rendered plainly visible to the naked eye and with low magnifications. These large blocks were cut at 25, 50, 75 and 100 microns.

To demonstrate the finer changes in the lesions, smaller blocks of tissue embedded in paraffin were cut at 8 microns and frozen sections at from 10 to 20 microns. Weigert's myelin sheath stain and the Marchi method were employed, but the latter was found to be limited in its usefulness. Although the general stains, such as van Gieson's and hematoxylin and eosin, do not differentiate the individual elements, they were of great value for the inflammatory and other structural changes. As a substitute for the Marchi method Scharlach R was valuable, especially when used in conjunction with axis-cylinder stains and also with some of the glia stains.

The thionin stain was useful in demonstrating changes in the nerve cells and also in showing some of the glia and inflammatory reactions. This stain was especially valuable when used with some glia stains, to show the relation of glia cells to the nerve cells and to other unstained glia elements. For demonstrating axis cylinders, Orlandi's modification of the Bielschowsky method gave such excellent results that no other method was employed, as it can be used after fixation in formaldehyde and after embedding in paraffin, as well as in frozen sections. The results obtained were uniformly satisfactory, although it sometimes stains glia cells faintly and also connective tissue, but these can easily be distinguished from nerve cells and axis cylinders. This impregnation method was particularly useful in conjunction with the Scharlach R stain. Various glia stains were used, but the most valuable were Cajal's gold chloride sublimate method and del Rio-Hortega's silver carbonate method. The Penfield modification of del Rio-Hortega's method for oligodendroglia was valuable, and a thionin counterstain showed the relation of these cells to other elements unstained by the silver carbonate. Cajal's gold chloride sublimate method gave satisfactory results after the ordinary fixation in formaldehyde. In addition to these, the Weigert glia stain, the Alzheimer-Mann stain, Mallory's phosphotungstic acid hematoxylin stain (case 2) and the orange G stain were used. The first two were the most satisfactory, as they demonstrated the four types of glia cells and most of their reactions as far as is known at present, but were supported by the other methods. A slight modification [3] in Meyer's mucicarmine stain was used in an endeavor to demonstrate the presence of mucus.

GROSS SECTIONS (CASE 1)

In the coronal section (fig. 1) through the occipital lobe of the left hemisphere, extensive demyelinization of almost the entire white matter had taken place. Occasionally, myelinated arcuate fibers remained, particularly around the calcarine fissure, in the convolutions above and in those below it. Some were also preserved in the convolutions on the superior surface of the lobe, but on the lateral aspect myelin of the short association fibers was absent. This was also true elsewhere throughout the section. As far as could be determined by the naked eye and with the aid of a hand lens, the gray matter was preserved intact except at the depth of an occasional convolution, where it had the appearance of being "nibbled into," and the outline was indistinct. In the area striata the stria of Gennari was preserved, although in some places it could not be seen in the unstained sections. It the middle of the degenerated white substance, cysts or hemorrhages could not be seen.

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3. Mordanting formaldehyde-fixed tissue in saturated aqueous solution of picric acid (75 cc.) and glacial acetic acid (5 cc.).

In a coronal section through the cerebrum at the middle of the temporal lobe (fig. 2) the lesion was not so extensive and was limited, for the most part, to the lower half of the section. In the temporal lobe most of the white matter had been destroyed, only the association bundles being preserved, and even these in some places had disappeared. The greater portion of the lesion in this section was below the level of the middle of the insula and the middle of the external capsule, the lower half of which was destroyed, and was also below the lenticular nucleus. In the optic tract, the upper half was demyelinated, while the lower half was apparently intact. Medial to the optic tract the basis pedunculi had a narrow area of degeneration involving its lower medial portion. The upper edge of the lesion was not a straight, sharp line, but many projections could be seen invading the neighboring white matter; even in the temporal lobe itself the degeneration was not uniform, but appeared mottled and unequal in its distribution. The edges of

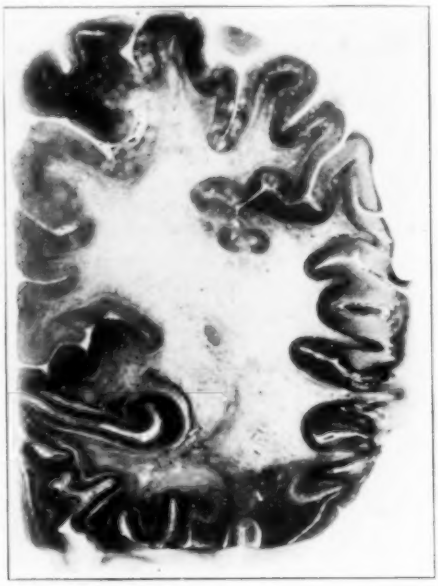


Fig. 1.—Coronal section (100 microns) of left occipital lobe, showing complete demyelinization of the medullary substance, even the arcuate fibers having disappeared; Weigert myelin sheath stain.

some of these areas were clearcut and sharply demarcated, but others appeared to merge gradually into the surrounding tissue.

The white matter of the upper half of the section was not free from areas of demyelinization, as two distinct plaques could be seen, one in the corona radiata beneath the cortex. Its edges were not sharply demarcated, but the degenerated part gradually merged into the normal tissue. The other plaque was a small oval-shaped area above the corpus callosum and beneath the gyrus cinguli. Throughout the remainder of the white matter, on examination with a hand lens, multiple small areas of partial demyelinization could be seen with a small vessel in the center of each. Occasionally, similar small areas did not contain a central vessel; such areas were present in the tangential fibers of the hippocampus. There

was only one cystic area, superolateral to the anterior commissure and the tail of the caudate nucleus.

In a section through the anterior third of the temporal lobe, degeneration was much less and, in fact, was only present as partly demyelinated areas around blood vessels situated below the inferior extremity of the claustrum. Here again the association fibers, which lay in close approximation to this area of partial demyelinization, were intact. The fibers of the temporal lobe at this level appeared normal, as did all the fibers above the basal nuclei.

A section near the tip of the frontal lobe showed one small rounded demyelinated area in the white matter medial to the inferior frontal convolution. There was

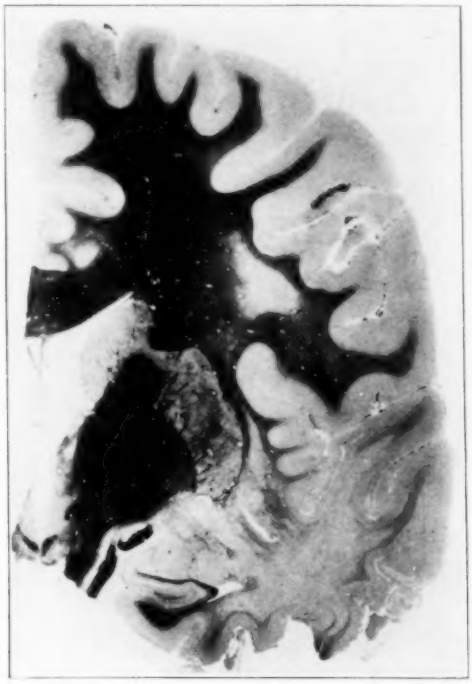


Fig. 2.—Coronal section (75 microns) of the left hemisphere at about the level of the anterior third of the degenerated temporal lobe. Arcuate fibers are preserved in many places. Two independent areas of demyelinization, half of the optic tract and part of the peduncle are shown; Weigert myelin sheath stain.

another larger plaque medial to the middle frontal convolution; otherwise, the white matter was normal.

A horizontal section through the right hemisphere, passing through the body of the corpus callosum midway between its superior and inferior surface (fig. 3), showed extensive degeneration in the fiber tracts of the occipital lobe, while the frontal lobe was relatively free. In the occipital lobe the entire white matter had been completely destroyed, even the myelin of the majority of the association fibers having disappeared. This demyelinization process had advanced forward to the level of the posterior part of the body of the corpus callosum and laterally

to the cortex. The anterior edge was irregular and merged gradually into the normal tissue. The anterior half of this section showed that there were many small partially demyelinated areas with a blood vessel in the center. Some of these smaller foci had coalesced giving areas of appreciable size. The gray matter was normal everywhere except in the occipital lobe where, in some places, it had the appearance of being "nibbled into."

In a section at the level of the foramen of Monro (fig. 4), degeneration of the white matter of the posterior half of the section was present, while the anterior half

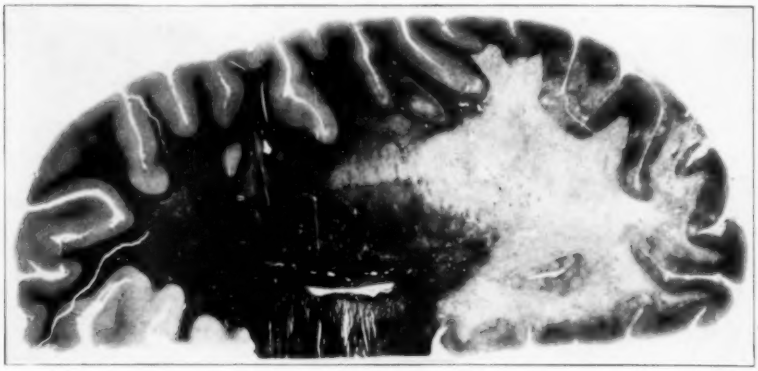


Fig 3.—Horizontal section (100 microns) of the right hemisphere, showing demyelinization of the posterior half of the section. The arcuate fibers have disappeared in the greater portion of the occipital lobe; Weigert myelin sheath stain.

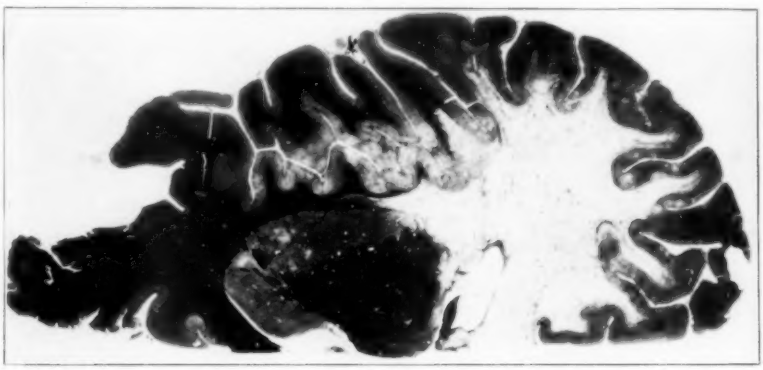


Fig. 4.—Horizontal section (75 microns) of the right hemisphere at a lower level than that of the section shown in figure 3. The lesion involves the splenium of the corpus callosum, the posterior portion of the internal capsule and also of the external capsule. Arcuate fibers are not present; Weigert myelin sheath stain.

of the section appeared to be relatively normal. As in the previous section, demyelinization was complete in the occipital lobe, and even the association fibers were absent. Cysts could not be seen in the degenerated area. The lesions involved the optic radiations, but the stria of Gennari was fairly well preserved,

and more anteriorly there was destruction of the myelin in the splenium of the corpus callosum and in the tissues around the inferior horn of the lateral ventricle. The posterior part of the internal capsule was degenerated as were the fibers in the posterior part of the thalamus, in the posterior part of the external capsule and those between the claustrum and the insula. Anterior to that part of the external capsule which was completely destroyed, there was partial demyelinization, especially around the small blood vessels, giving it a mottled appearance. Occasionally, similar small areas could be seen anterior to the claustrum even at a distance from the main mass of the degeneration.

At a still lower level (fig. 5), in a section through the optic tract, hippocampus and a portion of the peduncle, degeneration was present to a marked degree. Practically no myelin was present in the section. At the tip of the occipital lobe the association bundles remained, but they were absent from the lateral side of the hemisphere up to the tip of the temporal lobe. Little of the frontal lobe was seen in this section, but the myelin of the tuberculum olfactorium was preserved.

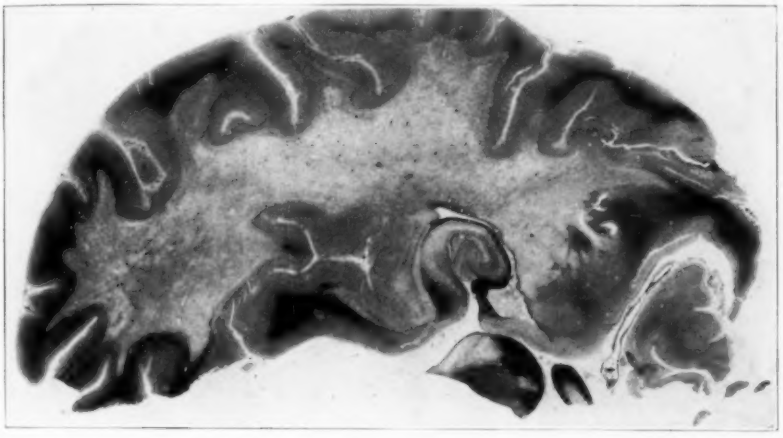


Fig. 5.—Horizontal section (75 microns) at lower level than that of the section shown in figure 4. The myelin of almost the entire occipital and temporal lobes has been destroyed. The optic tract and the peduncle are present; Weigert myelin sheath stain.

The myelinated fibers were also preserved around the hippocampus, near the amygdaloid nucleus, and around the tail of the caudate nucleus. There were several patches of degeneration in the peduncle involving its lateral half, and another smaller patch was present in its medial third. In several sections at this level the optic tract, which was partially destroyed, could be seen curving around the peduncle toward the lateral geniculate body. The involvement of the optic tract was not uniform throughout its entire length.

At the level of the posterior end of the inferior colliculus, sections through the midbrain showed a considerable number of areas of degeneration in the pons, but the fibers of the median and lateral lemnisci and those of the decussation of the brachium conjunctivum were intact. In the pons the two largest areas were situated laterally. On the right side, in one section, the external arcuate fibers were preserved, but in other sections these fibers had been destroyed. On the left side the degeneration was beneath the pia mater. On the right, it extended

from the posterior edge of the median leminiscus backward, and medially it involved many of the transverse fibers of the pons and most of the fibers of the pyramidal tract. On the left this area was larger but did not extend as far anteriorly, so that pyramidal fibers were spared and more pontile fibers destroyed. One section, which contained the trochlear nerve, showed this small bundle of fibers to be at least partially demyelinated.

Sections through the pons (fig. 6) at the level of the emergence of the trigeminal nerve showed plaques on both sides which were almost symmetrical. The white matter of the cerebellum, as well as the brachium conjunctivum, appeared normal. There were two plaques in the brachium pontis on either side, involving approximately half of these bundles of fibers. The areas were elliptical with the concavity directed medially and slightly forward, and the convexity beneath the pia mater. The roots of the trigeminal nerves passed through these areas. A few of these fibers were preserved intact, but the majority were without myelin, as could easily be seen with the aid of a hand lens. The proximal

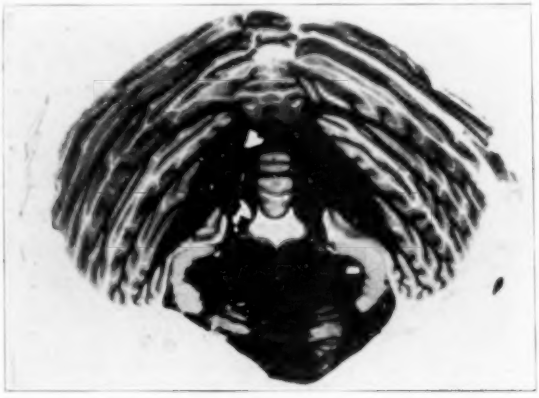


Fig. 6.—Section (50 microns) through the pons and fourth ventricle. Laterally situated and almost symmetric are areas through which the fifth nerve root is emerging. Degeneration of the pyramidal tracts; Weigert myelin and sheath stain.

portions of these fibers were better preserved than the distal. In the pons itself, the majority of the pontile fibers were intact, but most of the fiber bundles of the pyramidal tracts were destroyed especially the posterior and lateral groups.

FINER SECTIONS (CASE 1)

In the white matter in the center of either occipital lobe, where degeneration was most marked, studies with higher magnifications confirmed the observations of the large sections stained with the Weigert myelin sheath method. No myelin sheaths remained and with nerve fiber stain no axis cylinders were seen, not even fragments. General stains showed the tissues to be composed, for the most part, of various types of glia cells, some with clear or vacuolated bodies, some with solid homogeneous staining bodies and some with several nuclei. These "gemästete" (Schaltenbrand[4]) glia cells were well seen in the van Gieson stain (fig. 7); some

4. Schaltenbrand, Georg: Encephalitis Periaxialis Diffusa (Schilder), Arch. Neurol. & Psychiat. **18**:944 (Dec.) 1927.

had large cell bodies containing two or more nuclei and delicate processes were often present, but in some even these had disappeared. The areas between these cells were filled with delicate trabeculae and multiple small clear spaces. There were many nuclei scattered throughout without demonstrable cell bodies, and the perivascular spaces were distended containing scavenger cells and numerous inflammatory cells, that is, swollen endothelial cells and lymphocytes; but only a few polymorphonuclear leukocytes and no plasma cells were seen. Special stains demonstrated the various types of glia cells in this degenerated area. Alzheimer-Mann stain showed many astrocytes with swollen bodies and numerous delicate processes. Some of these cells had two or more nuclei, the gemästete glia cells. The majority of cells in this area were scavenger cells, and were well demonstrated by Penfield's modification of the silver carbonate method of del Rio-Hortega. Their bodies were large, irregular and vacuolated, staining unevenly, but occasionally they were clear, only the cell outline being seen. Scharlach R

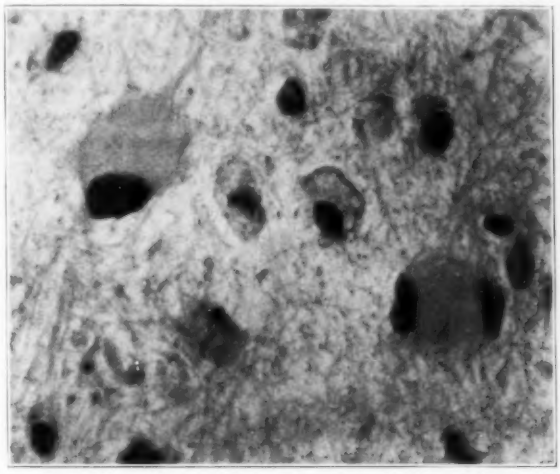


Fig. 7.—"Gemästete," globoid or giant glia cells with one or more nuclei. Compound granular corpuscles are also present; van Gieson stain; × 600.

stains showed some to be filled with lipoids but some, especially in the older degenerated portions, contained little fat, and many did not contain any or only small amounts in very small droplets. Cajal's gold sublimate method showed many astrocytes; few of these cells had their normal processes which were diminished in number and size, and most of the cells seemed to have lost their vascular connections. An occasional cell retained its vascular foot although all the other processes had almost entirely disappeared. Clasmatodendrosis in various stages was well shown. In some areas all traces of astrocytes had disappeared. Penfield's modification of del Rio-Hortega's stain for oligodendroglia did not show cells of this group in the middle of the degenerated area.

At the juncture of the degenerated with the normal tissue an entirely different histologic picture was seen. This area varied much in width; in some places the transition was abrupt, in others gradual. Some medullated fibers passed for a short distance into the degenerated area, but they were in an apparently unhealthy condition, the myelin sheath being swollen, irregular and nodular, and partly

broken up and collected in masses. The centers of the nodules were clear, giving the appearance of vacuolization. The course of the fibers was more tortuous than normal, wandering between the swollen and proliferated glia and compound granular cells. The endings of the myelin sheaths were not always abrupt. The myelin appeared swollen (fig. 8), staining less and less clearly, only the periphery of the sheath taking on the stain, and finally it became indistinct. In some places the sheaths were fragmented and swollen so that it appeared as if swollen droplets of myelin, staining more or less distinctly, were scattered throughout the microscopic field. With the Scharlach R stain, some of these swollen nodular and tortuous myelin sheaths showed a faint reaction for lipoid along the periphery, but the majority of the sheaths did not react thus and the vacuoles did not, as a rule, contain free stainable fat. The fragmented myelin reacted in a similar way, only some fragments stained for fat and even these had only small stainable granules at the periphery; occasionally a larger globule of fat could be seen in

Fig. 8.—Tortuous and swollen myelin sheaths with a moniliform appearance. These sheaths are irregularly arranged; Weigert myelin sheath stain; ×250.

either a tortuous myelin sheath or a fragmented one, but these globules were uncommon.

The axis cylinders were well preserved when the myelin was normal, but when the myelin was swollen, nodular and irregular, the axis cylinders showed a similar but milder change. Occasionally, an axis cylinder was seen to proceed for a short distance into the degenerated tissue, but these fibers were not numerous and most of them were coarse and heavy, running in straight lines. Many of the axis cylinders were nodular, swollen, granular and fragmented (fig. 9). The fragments were tortuous, and some small pieces were engulfed by compound granular cells. On the whole, however, the axis cylinders were better preserved than the myelin, and the fragments could be seen in areas in which the myelin was completely absorbed. A combination of the Orlandi axis-cylinder method and the Scharlach R stain showed that the axis cylinders were preserved at a greater distance in the degenerated areas than the myelin sheaths. Where the myelin was swollen and in the process of breaking down, the nerve

fibers were also swollen and fragmented, but they persisted longer than the myelin. Cells of microglia origin were numerous and with the Weigert myelin sheath stain these cells could be seen to contain small masses of myelin which had not degenerated but stained with hematoxylin (fig. 10). These small pieces were often swollen, but nevertheless stained blue like normal myelin. With the Scharlach R and hematoxylin stains, the scavenger cells were seen to be most numerous a short distance behind the advancing edge of the degeneration. Some contained large droplets of fat, while others contained many small granules. In an occasional cell, granules of myelin in various stages of degeneration could be seen. These gave a lipoid reaction at the periphery of the granule, and the remainder stained blue with hematoxylin, so that in this rapid degeneration of myelin sheaths and hyperactivity of the microglia cells, the myelin was ingested before it broke down into its component parts (fig. 11).

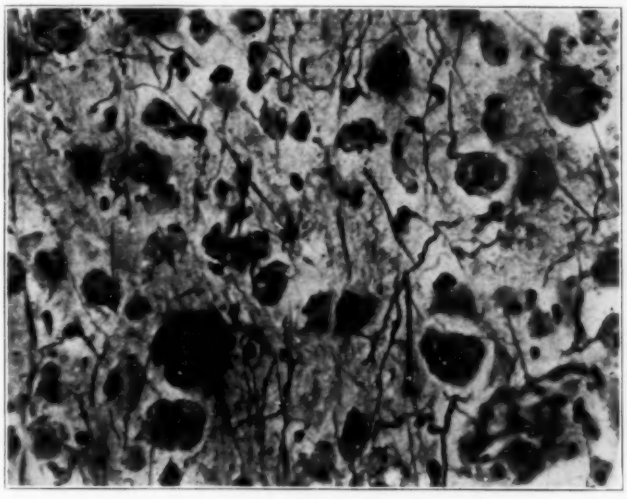


Fig. 9.—Tortuous, fragmented and swollen axis-cylinders. Scavenger cells containing fat are seen; Orlandi axis-cylinder method and Scharlach R. stain; $\times 300$.

These cells when stained with the Orlandi axis-cylinder method and Scharlach R stain showed, in addition to the fat granules, fragments of the axis cylinder within the swollen cell body. Most of these small pieces of nerve fibers were swollen and some of them were in spiral form. Many cells contained axis-cylinder débris and small granules. The compound granular cells containing the axis-cylinder débris were deeper in the degenerated area than were those containing the fat droplets. Most of the perivascular spaces were distended with these large scavenger cells. There were other small cells of various types in the perivascular spaces, but these did not differ from those described in the degenerated area. Scavenger cells could also be seen in the perivascular spaces in the apparently normal tissue, but near the edge of the degeneration. Penfield's modification of del Rio-Hortega's method for microglia showed these cells in the process of changing into scavenger cells at the advancing edge of the lesion. In spite of the fact that the processes were granular and swollen and the cell body enlarged and

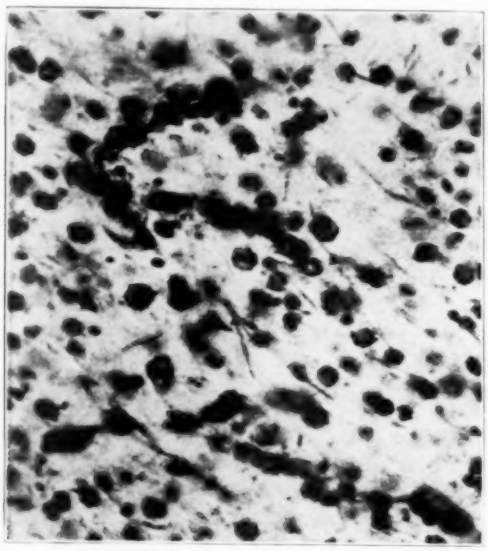


Fig. 10.—Phagocytosed myelin masses within compound granular cells. A few fragmented myelin sheaths can be seen; Weigert myelin sheath stain; × 160.

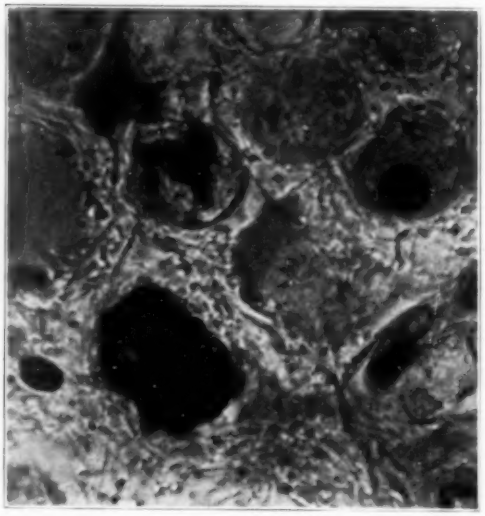


Fig. 11.—Globular myelin masses within scavenger cells. One cell gorged and one containing only a few rounded masses. Some other scavenger cells without stainable myelin; Pal-Weigert stain with carmine counterstain; × 1025.

vacuolated, a Schlarach R counterstain did not, at this stage of the development of the "Gitterzellen," reveal free fat within the cell body, and fat appeared only after the cells had developed more fully. A hematoxylin counterstain showed the cells to contain small bluish masses and granules. The myelin apparently was absorbed before breaking down into its component parts, of which free stainable fat is one part. Pal's modification of the Weigert myelin sheath stain with thionin or carmine counterstain showed some of these scavenger cells in the degenerated area to contain myelin as yet unchanged in staining reaction but broken into small masses. This was shown even by the ordinary myelin sheath stain.

Penfield's modification of del Rio-Hortega's silver carbonate method for oligodendroglia showed these cells to have undergone the process of acute swelling, as described by Penfield and Cone.[5] In the degenerated area oligodendroglia cells could not be seen, but in the normal tissue, close to the degenerated area, acute swelling was well shown. The cell bodies were large and clear and the processes were, for the most part, absent, but occasionally a short thick process could be seen. Further in the normal tissue, the swelling had not advanced so far, and the cell bodies were not so large. The processes were larger and more numerous. The ends of the processes were usually seen as swollen, rounded bulbs. Often only one process was visible, but sometimes two or even three such processes were present.

It was difficult to demonstrate mucus in these swollen oligodendroglia cells in the quantity shown by Bailey and Schaltenbrand[6] and later by Schaltenbrand. Such cells have been called mucocytes by Grynfeltt.[7] Bailey and Schaltenbrand claimed that these mucocytes were identical with the acutely swollen oligodendroglia cells described by Penfield and Cone. Mucous stains in this case demonstrated that few of these oligodendroglia cells in the stage of early acute swelling contained mucus, even around the nucleus; only occasionally could such a cell be seen, and even then the amount of mucus was very small. Schaltenbrand has shown that oligodendroglia cells are absent from the degenerated areas in Schilder's disease; we have found a similar absence of these cells in this case, but our mucicarmine stain showed a large amount of mucus in the degenerated area, and there it was almost entirely contained in the Gitterzellen, even when present in the perivascular spaces. An occasional astrocyte was also seen to contain a small amount of mucus diffusely distributed in its cytoplasm, but these were present only in the degenerated area. Collections of mucus were scattered throughout and in the edge of the degenerated tissue; sometimes even small amounts could be seen in the normal tissue near the edge of the degeneration, and these masses were not intracellular.

Cajal's gold sublimate method demonstrated the astrocytic changes in the edge of the degeneration and also their changing into gemästete or globoid glia cells. Over a narrow zone there was well marked hypertrophy and hyperplasia of the astrocytes (fig. 12). These cells had larger bodies, while their processes were also larger and longer, but did not seem to be more numerous than normal. The vascular attachments were well preserved.

5. Penfield, W., and Cone, W.: Acute Regressive Changes of Neuroglia Ameboid Glia and Acute Swelling of Oligodendroglia), J. Psychol. u. Neurol. **34**:204, 1926.

6. Bailey, P., and Schaltenbrand, Georg: Die muköse Degeneration der Oligodendroglia, Deutsche Ztschr. f. Nervenh. **97**:231, 1927.

7. Grynfeltt, E.: Mucocytes et leur signification dans le processus d'inflammation chronique des centres cérébrospinaux, Compt. rend. Soc. de biol. **89**:1264, 1923.

There was an abrupt transition between the normal and degenerated tissue as determined by this method. The processes of the astrocytes became swollen, vacuolated, fragmented and irregular. Scavenger cells were attached to these nodular processes which became short with abrupt endings and indistinct outlines. Some of the scavenger cells, with this method of staining, were seen to contain stained granules, probably phagocytosed pieces of astrocytic processes. Occasionally, for considerable distances in the degenerated area, astrocytes with long and well preserved processes were present, but such cells were rare. Vascular attachments seemed to be preserved longer than most of the other processes. With the van Gieson stain, the astrocytes were changed into the giant glia cells or the

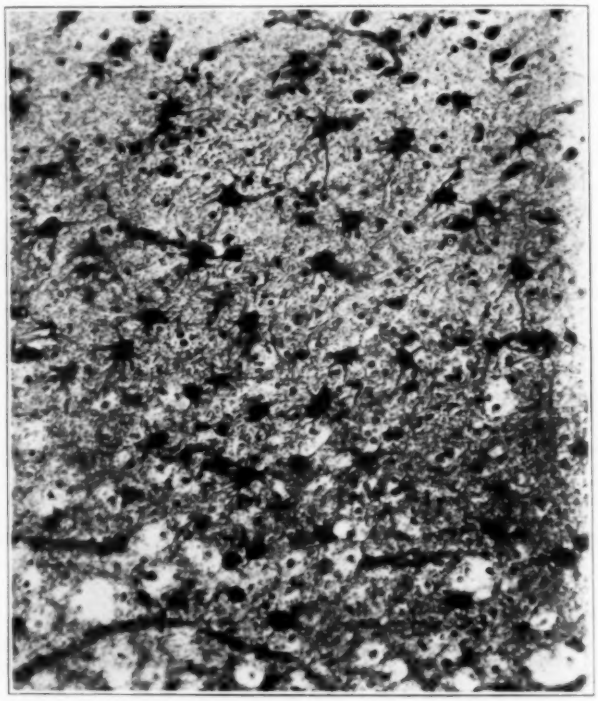


Fig. 12.—Astrocytes at zone of demarcation, showing increase in numbers and in size of both cell body and processes. Normal tissue at top, degenerated tissue below. Degenerative changes in the astrocytes with loss of the processes and so forth are shown; Cajal's gold sublimate method; × 300.

gemästete glia cells with two or more nuclei and large homogeneous-staining cell bodies with a few short delicate processes. Mallory's orange G stain demonstrated these cells even better and showed their processes to be longer than could be seen with the van Gieson stain, but nevertheless they were, as a rule, delicate, although some cells retained coarser processes which were usually swollen, nodular and irregular.

Except in areas in which the degeneration encroached on the gray matter, the fibers in the cortex and coming from it were apparently normal, and where the degeneration had invaded the cortex only the deep fibers, as a rule, were

destroyed. The changes observed in both the myelin sheaths and the axis cylinders were similar to those described elsewhere as present at the edge of the degeneration. When this edge was in the cortex, the line of demarcation was much more abrupt than elsewhere. The astrocytes formed a definite narrow band with an excessive number of long interlacing processes producing a sort of fibrous barricade. These astrocytes were similar to those already described. In areas, even at some distance from the edge of the degenerated area, the oliodendroglia cells showed acute swelling. The closer these cells were to the degeneration, the more pronounced was the swelling. There was marked satellitosis; the satellite cells were well demonstrated in a combination of the Penfield modification for

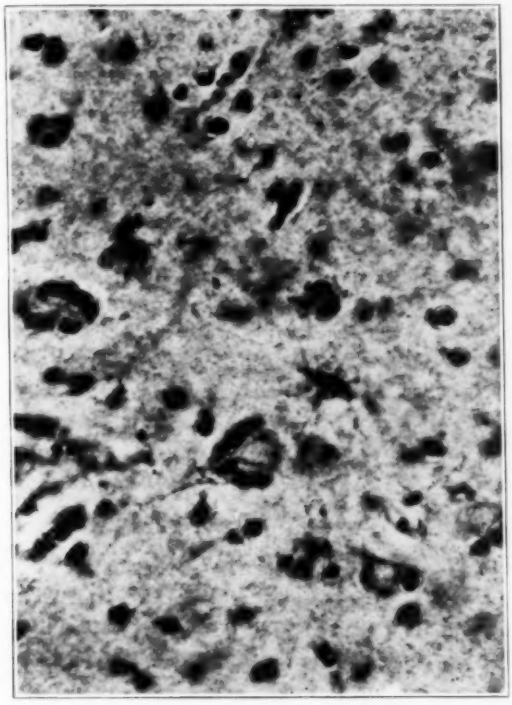


Fig. 13.—Acutely swollen oligodendroglia cells. Satellitosis is shown; Penfield's modification of del Rio-Hortega's silver carbonate method for oligodendroglia with thionin counterstain; × 320.

oligondendroglia and a thionin stain (fig. 13). The relationship of the satellite cells to the ganglion cells was well shown, but it did not appear that these cells took any part in phagocytosis. Thionin stains of the cortex showed that the nerve cells, unless directly involved in the degenerative lesion, in the occipital lobes, as mentioned, were on the whole well preserved. In close proximity to the degeneration, satellitosis was marked, and the nerve cells showed some evidences of mild chromatolysis. In areas in which the association fibers were intact, the overlying gray matter appeared to be normal except for the satellitosis which was found even in the gray matter at considerable distances from the degeneration. Some oligodendroglia cells were normal, but most of them showed acute swelling.

Both at the edge of the degeneration and in the normal tissue, at short distances from the advancing edge, perivascular infiltration with small cells was a prominent feature. These perivascular collections of cells were limited to the edge of the degenerated area and were absent from the normal tissues and the cortex. Some of these cells were lymphocytes, and some were swollen endothelial cells. An occasional pyknotic nucleus without any cell body could be seen, but for the most part the cells were of the scavenger type. It was unusual to see any polymorphonuclear leukocytes in the perivascular spaces.

In the white matter in the frontal lobe, at the greatest possible distance from the degeneration, no unusual observation was noted, except that clear spaces were seen around some of the smaller vessels, similar to lesions described in the brains in certain cases of pernicious anemia associated with combined sclerosis. These halos were larger and more numerous near the degeneration and appeared to be produced by edema. In and around some of these spaces, the myelin sheaths were swollen and nodular, but usually they appeared normal. In a few of these perivascular spaces, there was an increase in the cellular elements. In the white matter a large number of small clear spaces could also be seen in which there was a nucleus. These spaces were more numerous nearer the degenerated tissue, but were present at a considerable distance from it. With the del Rio-Hortega method they were shown as oligodendroglia cells in the stage of acute swelling.

Blood Vessels.—In the degenerated area, especially near its edge, the perivascular spaces were distended with scavenger and other cells, but there was also some thickening of the walls of the arteries. Part, at least, of this could be accounted for by edema, but there was an increase in the perivascular connective tissue and some increase in the connective tissue of the media. In the smaller arteries and arterioles, there was also proliferation of the lining endothelium which, in some places, seemed almost to occlude the lumen of the vessel. This intimal proliferation was most marked in the vessels near the edge of the degeneration, especially in the normal-appearing tissue and even in the smaller vessels at a distance from the degeneration. The smaller cortical vessels showed this endothelial proliferation in its most marked degree, especially in the occipital regions, so that it stimulated the changes seen in vessels in cases of endarteritis proliferans. The large vessels did not show any appreciable changes in the intima.

The meningeal vessels were essentially normal. In the meninges there was a considerable number of lymphocytes, but no signs of acute inflammation or of scavenger cells were present.

Cranial Nerves.—Unfortunately, microscopic study of all the cranial nerves was not possible, but several were examined and showed degenerative lesions. Both optic nerves had areas of degeneration, but complete destruction was not present. In the left near the optic chiasm, about one third of the fibers were destroyed, and many of those remaining were in various stages of degeneration. The myelin was swollen and vacuolated as was seen in the edge of the other areas of demyelinization. Astrocytes were proliferating and were in various stages of degeneration and gemästete-cell formation. The scavenger cells were abundant, and the perivascular spaces contained many of them. In a section nearer the globe the fibers were almost intact. The optic tracts showed an equal amount of destruction. The superior half was completely demyelinated while the inferior half was intact, and the line of demarcation was sharp. This degeneration was a recent process, and several small hemorrhages were present.

The myelin sheaths of the fourth nerve within the gray substance were normal until they emerged from the roof of the midbrain. After their emergence, they were demyelinated and almost completely degenerated, especially in the center of

the nerve bundle. The peripheral fibers were better preserved, but showed signs of degeneration.

The changes in both the fifth nerves were almost entirely within the brain stem. Both passed through the symmetrically situated plaques at the lateral sides of the pons. A few fibers appeared to pass through these plaques intact, but the majority of the myelin sheaths had disappeared. Where a bundle of fibers was large, the centrally situated ones escaped demyelinzation, but the more peripherally situated ones were destroyed; the intermediate fibers were seen in various stages of degeneration. Unfortunately, no other cranial nerves were available for study.

Secondary Degeneration.—Secondary degeneration was not so abundant as might be expected. The outstanding examples were shown in the corticospinal tract. As has been mentioned, there was degeneration of a part of the internal capsules and pedunculi which could be traced down through the pons, where in one situation the pontile fibers were preserved intact, while the corticospinal fibers were almost completely destroyed. On tracing this further, down to the decussation of the pyramidal tracts, practically no fibers remained intact, and with the Marchi stain little acute degeneration was present.

The axis cylinders for the most part were better preserved than the myelin sheaths. There were also some polymorphonuclear leukocytes and lymphocytes in the perivascular spaces while the vessel walls were thickened much like those in the cerebrum. Slight glia proliferation was also seen, but little connective tissue could be demonstrated. All the other descending and ascending fiber tracts at this level were apparently normal. Throughout the other portions of the central nervous system it was difficult to differentiate primary and secondary degeneration, because of the diffuseness of the lesion. The pyramidal degenerations were undoubtedly secondary as they could be traced from above downward, and in the cervical cord the corticospinal tracts were the only ones involved.

GROSS SECTIONS (CASE 2)

In the Weigert myelin sheath stain of coronal sections through the occipital poles (fig. 14), the left appeared normal, but the right showed extensive degeneration which involved the greater portion of the white matter. The only myelin tissue remaining was that in the outer and lower third, and around most of the arcuate fibers. The gray matter seemed to have been preserved intact even in the few places in which the arcuate fibers were destroyed. The center of the degenerated area had a peculiar mottled appearance due to clear areas around the blood vessels. The line of demarcation between the normal and the demyelinated tissue appeared sharp and was indistinct only where the arcuate fibers had been involved in the lesion. With the aid of a hand lens the edge was not so distinct; even in the normal-appearing tissues at short distances from the degeneration there appeared to be clear spaces around some of the smaller vessels. These halos became larger and coalesced on approaching the demyelinated tissue.

In a coronal section through the middle of the occipital lobes there was a demyelinated area in the left side and two in the right. The one in the left occupied the superior and median third. Degeneration of the white matter was complete and seemed to have progressed to the stage of cyst formation. Many of the arcuate fibers had been destroyed, and the process invaded the white matter. In most places the line of demarcation between the degenerated and the white matter appeared sharp, but here and there the transition was gradual over a distance of several millimeters, and with a hand lens this gradation appeared to be due to fusion of clear spaces around some of the smaller blood vessels. In the right

side the two areas of degeneration were separate and distinct. One was below the superolateral surface, while the other was underneath the inferior and medial surfaces. The latter occupied the area around the calcarine fissure and the white matter beneath it. The line of demarcation was not distinct. The other degenerated area was larger, and the demyelinization was more complete. Its inferior edge was sharp but either the superior and lateral margins invaded the white matter or else the line of demarcation was indistinct and widened. Clear spaces around some of the vessels were prominent. The medullary rays in some of the overlying convolutions had completely disappeared.

In a section through the level of the red nucleus (fig. 15) there was a large plaque on either side, that on the left being much larger. On the right it was superior to the fissure of Sylvius, and irregular in outline and in density. The arcuate fibers on the upper surface of the fissure of Sylvius were destroyed as were most of the medullary rays. The line of demarcation between this area and

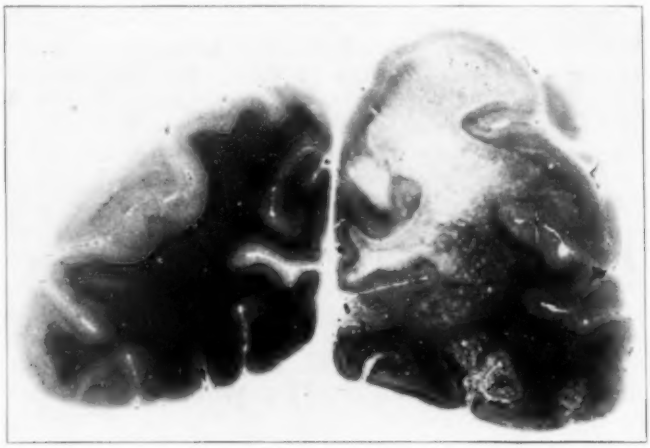


Fig. 14.—Coronal section (100 microns) of the occipital lobes. Degeneration of the medullary substance of the right hemisphere and disappearance of many of the arcuate fibers; Weigert myelin sheath stain.

the surrounding tissue was indistinct on its lateral surface and the lower half of its median surface, but the superior and upper half of its median edge was sharply demarcated. The area in the left hemisphere was extensive, involving more than half of the white matter and was still more irregular in outline than that on the right. There were areas of different degrees of myelin destruction; in places this was complete and in others only partially so. The corpus callosum was slightly involved, but the basal nuclei were untouched. The degeneration had not involved any tissues below the level of the fissure of Sylvius except to a slight extent in the left hemisphere. The subependymal tissues around the left lateral ventricle were involved on its superior and lateral borders.

In a section (fig. 16) through the tip of the lenticular nuclei degeneration was not present in the left hemisphere, while in the right the superior and lateral half was extensively destroyed. The demyelinization was complete, and disappearance of the tissues in one place had occurred with the formation of a cyst. Lateral to this cyst, the cortical tissues were invaded by the lesion, but elsewhere the arcuate fibers were preserved. On the upper half of the median surface the plaque

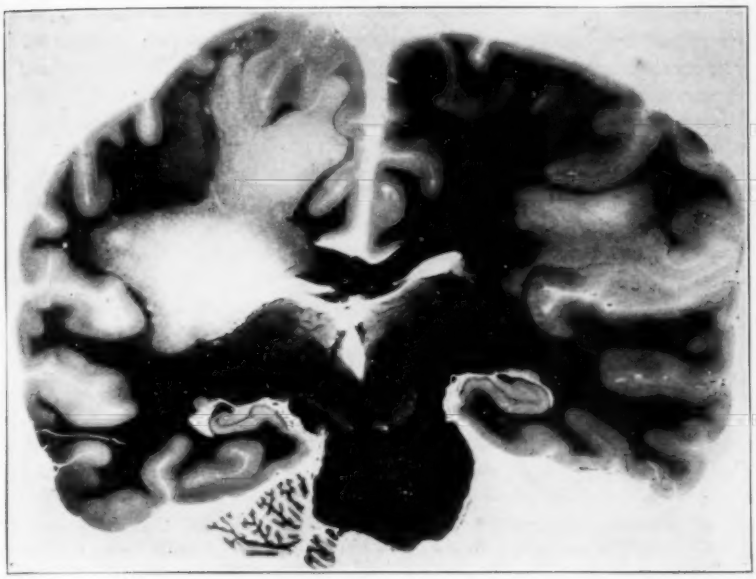


Fig. 15.—Section (100 microns) showing degeneration of both hemispheres, more extensive on the left than on the right. Arcuate fibers are destroyed in some places on both sides; Weigert myelin sheath stain.

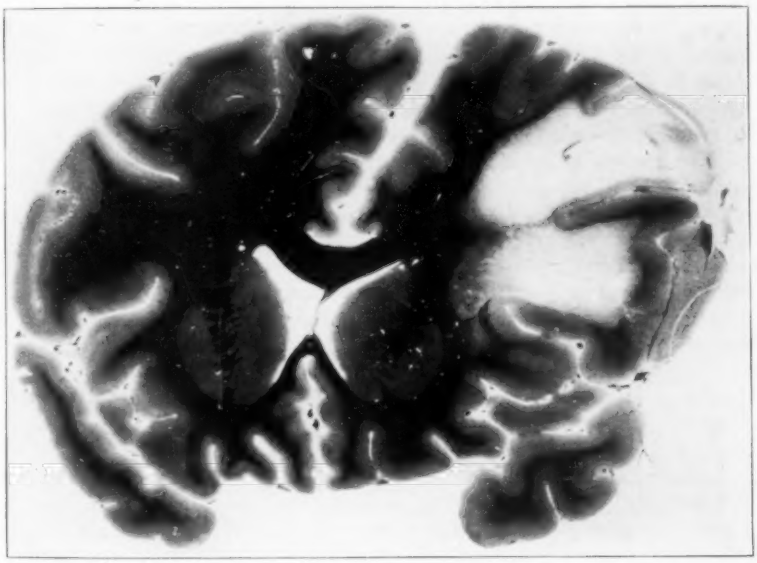


Fig. 16.—Section (100 microns) showing area of demyelinization on the right involving the cortex in one place; Weigert myelin sheath stain.

was sharply outlined, but the lower and median border had an indistinct outline. The lower half of this degenerated area had a mottled appearance with clear spaces around the vessels both in and around the plaque.

The most anterior section through the middle of the frontal lobes showed that degeneration was not present in the left side, but two plaques were present on the right underneath the cortex on its lateral aspect. These two plaques were close together, demyelinization was complete and their median borders were sharply outlined. In the upper area the arcuate fibers had been completely destroyed, but the medullary rays were preserved. The lower plaque had not destroyed the arcuate fibers on its upper surface, but its lower border invaded the gray matter, although the tangential fibers were preserved. The white matter underneath the middle frontal convolution was partly demyelinated and had many small clear areas, in the midst of each of which a vessel was located.

FINER SECTIONS (CASE 2)

With the higher magnification the center of one of the larger degenerated areas showed that myelin sheaths had not been preserved and that the axis cylinders had completely disappeared. General stains demonstrated that this area was made up of large scavenger cells, an occasional gemästete glia cell and considerable granular débris not phagocytosed, while the greater part was composed of unstained spaces. A Scharlach R stain showed that some of these scavenger cells, but not by any means all of them, contained fat. Special glia stains demonstrated that all normal astrocytes had disappeared, and even the gemastete glia cells were present only in small numbers. The vascular feet, which apparently persist longer than most other processes, had also completely disappeared. With the Cajal gold sublimate method, however, fragments of many processes could be seen diffusely scattered throughout the center of this area of degeneration, and an occasional scavenger cell contained fragments of these processes. With an axis-cylinder stain these same cells also contained fragments of axis cylinders, usually curled up but occasionally as small particles. The normal or acutely swollen oligodendroglia cells had completey disappeared while the swollen microglia cells were the most numerous of the cellular elements. A Pal-Weigert stain with a thionin or carmine counterstain showed that many of these scavenger cells contained normally-staining myelin. This was usually finely divided, simply giving the cell a bluish granular appearance; some cells contained large masses of myelin rolled into balls and sometimes small straight pieces of swollen myelin. In some places more than half of the scavenger cells contained normally-staining myelin, but usually they were less abundant. With a microglia stain these myelin-containing cells did not possess processes, and with a Scharlach R counterstain they did not show lipoid change. The perivascular spaces contained varying numbers of cells, which were not so numerous in the middle of the degeneration as near its edge. In the middle, most cells were of the compound granular type although there were lymphocytes, an occasional polymorphonuclear leukocyte and some swollen endothelial cells. A few small recent hemorrhagic areas were present. In the perivascular spaces, an occasional scavenger cell contained iron-free pigment. Nearer the edge of the area of degeneration, perivascular collections of cells were more pronounced, and here the predominating cell was of the scavenger type containing large amounts of soluble lipoids. Few polymorphonuclear leukocytes were present, a fact which suggested that the reaction was not truly inflammatory. Some nuclei without apparent cell bodies were seen. Stains for mucus revealed the presence of this substance in the scavenger cells throughout the area of degeneration, and these so-called mucocytes were well shown in some

of the perivascular spaces. It has not been possible to stain for fat and mucus simultaneously to determine whether both substances were present at the same time or whether mucus increased as the fat decreased. Mucus was present in greater abundance in the center of the degenerated area than near the edge, but in the case of fat the reverse was true.

In the edge of the degenerated area the microscopic picture was different from that in the middle of the demyelinated area and was similar to that described in case 1. The edge was as a rule more abrupt than in case 1, but an occasional myelinated fiber proceeded for a considerable distance into the degenerated area. The myelinization did not terminate sharply as if cut off, but the sheaths were swollen, nodular and tortuous with globules here and there along their courses, especially near their terminations. All sheaths were not like this; some seemed to degenerate and contain free fat before any of the foregoing changes occurred so that a combination of Scharlach R and Orlandi's axis-cylinder stain showed the relation of sheath to axon clearly. The majority of axis cylinders were fragmented and tortuous, and most of the pieces were swollen and beaded. They were apparently preserved longer than the myelin sheaths, and some of them proceeded for a considerable distance into the degenerated area, but none was preserved intact. Often they had a granular appearance. Occasionally, with the Orlandi stain, the scavenger cells had apparently phagocytosed small pieces of axons. Sometimes these cells contained only minute fragments, so that they had a distinctly granular appearance. Scharlach R stain demonstrated large amounts of fat in the zone between the normal and degenerated areas. Most of the fat was contained in the compound granular cells, but sometimes it was seen in myelin sheaths not yet completely disintegrated and phagocytosed, and sometimes the sheaths were swollen, nodular and had the appearance of vacuoles with the periphery taking the fat stain. Few of the scavenger cells had any processes, simply appearing as rounded droplets of fat usually with one nucleus but sometimes two nuclei. With Penfield's modification of del Rio-Hortega's silver carbonate method for microglia this area between normal and degenerated tissue afforded excellent opportunity for observing the transition of microglia into the so-called compound granular cells, Gitterzellen or scavenger cells. This process had been well demonstrated by del Rio-Hortega and Penfield so that it is unnecessary to discuss it here except to note that only in the cells that were fully developed scavenger cells was it possible to demonstrate free fat as a part of the content although they may have been seen to be attached to masses of myelin or other detritus. Cajal's gold sublimate stain demonstrated that there was marked hyperplasia of the astrocytes at the edge of the degeneration, especially in the normal tissue. These cells were increased in both number and size; their processes in particular appeared to be longer and more tortuous. There was no indication of how this increase came about, whether by migration or by proliferation, and all cells had well developed vascular processes. There was an attempt on the part of the astrocytes to form a barrier against the progress of the degeneration. In that part of the marginal zone nearest the degeneration there was definite destruction of the astrocytes which were seen in all stages of clasmatodendrosis, more advanced the deeper they were found in the demyelinated tissue. Penfield's modification of the del Rio-Hortega silver carbonate method for oligodendroglia showed that these cells were present in all stages of acute swelling. In the more degenerated tissue oligodendroglia cells had completely disappeared, while in the edge of the normal tissue they showed early acute swelling with slight distention of the cell body and retention of the processes. As the swelling advanced the processes were retracted, swollen and nodular, or had disappeared, the cell body became larger and the perinuclear clear space became wider until there was a large vacuole around the nucleus, and the outline of the cell became indistinct until

finally the naked nucleus alone was seen. During these changes in the cell body, the nucleus shrank and became pyknotic so that by the time the cell body had ruptured and the nucleus had become free, it was a small, deeply-staining mass of chromatin of irregular outline. It may have been some of these nuclei that made up at least a part of the perivascular collections of cells or nuclei. There was slight thickening of the vessel walls, particularly the smaller arteries and arterioles. Most perivascular spaces were distended with scavenger cells which for the most part contained free stainable fat. Some compound granular cells in the perivascular spaces could be seen to contain unchanged myelin as these masses stained blue with the Weigert myelin sheath stain. The mucicarmine stain demonstrated that many cells in the perivascular collections were found to contain mucus. Besides these scavenger cells there were other types present in the perivascular spaces although the compound granular cells predominated. There were some lymphocytes and swollen endothelial cells as well as some pyknotic nuclei without demonstrable bodies.

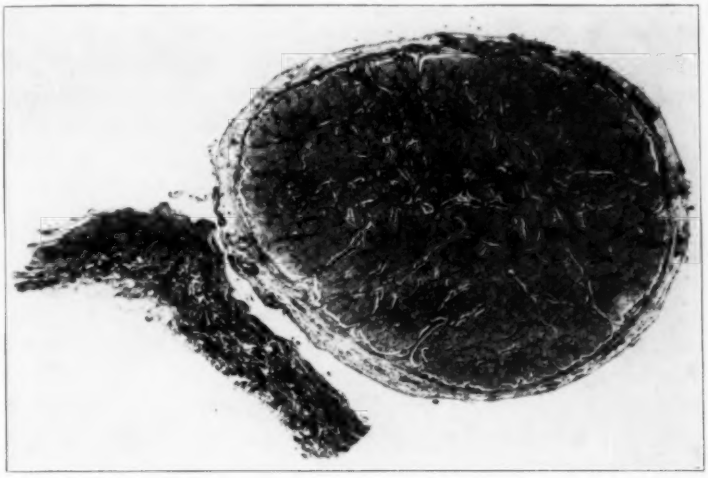
As a general rule the gray matter escaped the degenerative process and usually the association fibers were spared, but occasionally those fibers were destroyed and even the deeper layer of the gray matter was involved. In the gray matter the reaction was somewhat different and the transition zone was narrow. There was a wall of hyperplastic astrocytes between the degenerated and normal tissue, while in the relatively intact portion of the cortex there was a definite increase in the number of astrocytes. These astrocytes were larger than normal and their processes longer and more tortuous. This was particularly true in the cells that were nearer to the degeneration. Microglia cells were especially abundant, and satellitosis was present in an advanced degree. These pericellular oligodendroglia cells were in the stage of early acute swelling but retained their processes fairly well. Even when the degeneration was close they did not have the degree of swelling seen in those oligodendroglia cells observed at a similar distance from the degeneration in the white matter. Thionin stain showed chromatolysis and destruction of the ganglion cells close to the degeneration but further away; the Nissl bodies were present, even when satellitosis was evident.

In the normal white matter, even at distances of two or three microscopic fields from the edge of the degeneration, no unusual feature was noted. The myelin was normal in amount and distribution, and the axis cylinders were straight and regular. There appeared to be a slight increase in the numbers of astrocytes adjacent to the area of degeneration. Microglia cells appeared to be normal in number, size and shape, but the oligodendroglia cells showed early acute swelling which was present in a mild degree throughout the greater portion of the nervous system. It was only at considerable distances from the degeneration and even then only occasionally that normal-appearing cells were found. This was the only change found in the white matter aside from the degenerated areas. Perivascular infiltration was not seen and clear areas, such as those noted in case 1, were not present around the vessels. In and around the degenerated areas there was thickening of the walls of the vessels which appeared to be more than could be accounted for by edema alone. This intimal change was well marked in places, but it did not completely occlude the lumen of the vessel at any point. In all sections examined there was not a single vessel occluded by either thrombosis or intimal change. These mild vascular changes were seen in and around the degenerated areas, but otherwise the vessels were normal. No change was observed in the meninges.

Secondary degeneration, which was noted in case 1, was not present in this case, and the cranial nerves, with the exception of both optic nerves, were free from

degeneration. The optic nerves, as would be expected from the history, were completely degenerated. Weigert's myelin sheath stain (fig. 17) demonstrated that there was not a single normal myelin sheath present in either nerve and that some microglia cells contained ingested myelin as yet not disintegrated.

Marchi stains showed that degenerated myelin was not present except within compound granular cells which were present both throughout the tissue and in the perivascular spaces. Mallory's phosphotungstic acid hematoxylin stain demonstrated the fibers of the astrocytes and also the change of some astrocytes into giant or gemästete cells. There were signs of mild inflammation in these nerves, but this was difficult to classify since polymorphonuclear leukocytes were not present although lymphocytes and a few plasma cells were seen. Microglia and other neuroglia cells were abundant and also some pyknotic nuclei without demonstrable cell bodies. The cellular increase in the optic nerves seemed to be mainly of neuroglia and microglia origin.



Sec. 17.—Section (25 microns) of the right optic nerve showing destruction and complete disappearance of the myelin; Weigert myelin sheath stain.

COMMENT

These two cases differed in their clinical course and in the necropsy data. There was marked dissimilarity in the distribution and in the gross appearance of the lesions. This difference in distribution was more clearly demonstrated by the large Weigert sections, and yet the histologic observations in both cases were remarkably similar. Neither type of lesion could be placed on a vascular basis since the areas of degeneration did not correspond to the vascular distribution. On the whole, the cortex was well preserved, but the arcuate fibers were destroyed as many times as they were preserved.

From some of the observations it seemed that one possible method of progression of the lesion was along the perivascular spaces with the degeneration spreading from there into the surrounding tissue. The

perivascular edema, as evidenced by the halos, the early myelin destruction and the coalescence of these perivascular lesions in advance of the main degenerated mass tend to support this idea.

Our study confirmed the observation of certain previous observers that the axis cylinders were not preserved in the middle of the degenerated area but were present only at short distances from the edge of the lesion. As a matter of fact, they were destroyed, and they disappeared almost as soon as the myelin sheaths.

The usual teaching of myelin absorption was not entirely confirmed by some of the data in these two cases. Large numbers of scavenger cells were found containing masses of myelin which gave the normal myelin reaction with the Pal-Weigert stain. Some of these myelin bodies were breaking down, as was demonstrated with fat stains. The myelin sheaths were being fragmented more rapidly than they were disintegrating, so that relatively intact myelin masses were phagocytosed.

Degeneration of most of the cellular elements in the middle of the lesion was obvious, but the changes were not uniform even in all the components of one cell, and some cell processes disappeared more rapidly and earlier than others. The oligodendroglia reaction seemed to be the earliest response to injury. This response was seen in the form of early acute swelling which was progressive with the disappearance of these cells. The astrocytes were more resistant, and were attempting to form a fibrous barrier at the edge of the lesion. These astrocytes were hypertrophied and hyperplastic with long and tortuous processes. In the area of degeneration, the vascular processes of these cells seemed to be retained longer than any of the other processes.

Bailey and Schaltenbrand have shown that the mucocytes of Grynfeltt were identical with the acutely swollen oligodendroglia cells of Penfield and Cone. Our mucicarmine stains failed to reveal mucus in the oligodendroglia cells, but we found it in the scavenger cells, most abundant in the degenerated area and in the perivascular spaces. It was impossible to stain for fat and mucus simultaneously, but as the amount of fat in the compound granular corpuscles diminished, the mucus appeared to increase in amount or became more easily demonstrated. This may mean that the mucus was absorbed by these cells and not necessarily formed by them. Free mucus was not observed. Little evidence of acute infection was present, in spite of the fact that there was definite evidence of rapid progress clinically, so that we could not consider this process on a strictly inflammatory basis. The perivascular collections of cells could be accounted for on a degenerative and absorption basis.

The perivascular "cuffing" was limited to the edge of the lesion and only for a short distance in the normal tissue. The cortex was free from

these perivascular collections except where the lesion actually impinged on the gray matter.

Most of the cells in these perivascular spaces were easily identified. The nature of some of the pyknotic and naked nuclei could not be established. The possibility that at least some of these might be the nuclei of distintegrated oligodendroglia cells was considered.

The first case was a fairly classic example of Schilder's disease. The evolution of symptoms and signs, commencing with change in personality and diminution in auditory and visual acuity, and followed by convulsions, evidence of involvement of the pyramidal tracts, and finally quadriplegia with dementia, was indicative of widespread cerebral injury. The steadily progressive course and fatal termination served to confirm the diagnosis. The fulminating course of the second case with unilateral signs and increasing intracranial tension resembled in a general way Schilder's third case.[8] In the light of present knowledge, an attempt at diagnosis in such a case is only to hazard a guess that is based neither on reasoning nor on the law of probabilities.

ABSTRACT OF DISCUSSION

DR. BERNARD SACHS, New York: I have been very much interested in Schilder's disease. Up to the present time the great difficulty has been the definite recognition of these cases during life. So far as I know, few of them have actually been diagnosed during life.

If there are to be substantial contributions to this subject the important thing is to try to establish the cardinal clinical symptoms. It is evident, for instance, that the second case reported was not recognized during life, or I dare say the operation would not have been performed.

In the case that was recognized during life, the difficulty of differentiating it from other forms would seem to be great. So far as I can see, one would have to depend chiefly on a rapidly progressive blindness and deafness. I do not know that any of the other symptoms that have been mentioned that would help to establish the disease.

Is there a set of cardinal symptoms which if they were to occur in any other patient would be recognized as being pathognomonic or at least suggestive of Schilder's disease? That seems to me to be the information that is needed at the present time.

The histologic presentation is interesting. It seems to be an extremely diffuse and characteristic encephalitis.

DR. H. CUSHING, Boston: The neurosurgeon should be greatly interested in the malady that has been described. I will ask Dr. Bailey to tell you of a case of encephalitis periaxialis diffusa that was primarily referred to the Brigham Hospital because it was suspected that a tumor of the brain was present.

DR. P. BAILEY, Boston: There is only one case with which I am familiar and that case was diagnosed clinically by Dr. Georg Schaltenbrand. The diagnosis

8. Schilder, Paul: Die Encephalitis Periaxialis Diffusa, Arch. f. Psychiat. **21**:327, 1924.

was confirmed by Prof. Brouwer of Amsterdam, who happened to be there at the time. The patient was not operated on.

The diagnosis was based on rapidly developing blindness, with mental symptoms. This case was reported in the ARCHIVES. One interesting point in regard to the pathology of this condition was not brought out by Dr. Kernohan, I am sure because he did not have time, and that is the perivascular infiltration which occurs with these scavenger cells. The infiltration of the perivascular spaces with these macrophages occurred in our case only in the region of the lesion. That is to say, since this lesion was subcortical and only progressed slightly into the cortex, there was a certain extent of the blood vessels which was free from perivascular infiltration; hence, pathologic products were not carried along these vessels into the subarachnoid space.

DR. J. H. GLOBUS, New York: In order to be fair to all those who contributed on the subject I would like to put in a plea for Krabbe. I think that the best work on the subject of degenerative lesions in the subcortical regions of the brain is to be found in his two contributions.

I would also like to put in a word for myself. In 1922, Strauss and I reported a case which was diagnosed post mortem, and in 1926, we reported four cases of subcortical degenerative lesions in which one of the group had been recognized during life. We have substituted the term "subcortical degenerative encephalopathy" for the terms "Schilder's disease" and "encephalitis periaxialis diffusa." We found some clinical features characteristic of this disease. Given a child with a rather acute onset of cerebral involvement with a progressive course, in whom a diffuse lesion of the brain is suspected because of the appearance of blindness, deafness, mental deterioration and other disseminated lesions of the central nervous system, an inflammatory process having been excluded, a degenerative process may be postulated.

We have tried to find out if there is any relation between this condition and the Tay-Sachs disease. There is some evidence favoring such a possibility.

DR. S. BROCK, New York: Dr. Globus' terminology for this disease ic acceptable. It is, as he says, a subcortical encephalopathy without inflammatory characteristics. With his desire, however, to incorporate it in the Tay-Sachs group, I am quite out of sympathy. I think that both diseases show extreme swings of the pendulum; that Tay-Sachs disease is one affecting most, if not all, of the ganglion cells of the central nervous system, whereas the other affects almost solely white matter. Hence, the two are extremes and rather far apart. Nor do the clinical histories of the two diseases reveal similarities. Again, Tay-Sachs disease, with its strictly infantile and juvenile incidence, differs from this disease with its onset from infancy to middle age.

DR. J. B. DOYLE: In reply to Dr. Sachs I may say that we have formulated in our minds the type of syndrome that has been described, and that we have become more sensitive to the possibility of meeting this condition. In general, the most common symptoms of the disease are change in mentality, generally expressed as apathy, blindness, deafness, convulsions of one sort or another and evidence of disease of both pyramidal tracts. In other words, the most common type of clinical evidence is that indicative of general and bilateral signs of loss of the cerebral functions. As a rule, the pathologic process commences in the occipital lobe, and the symptomatology follows accordingly. Cases have been described, however, in which the process started in the frontal region and produced corresponding symptoms and signs.

In reply to Dr. Globus, I feel that we are not far apart in our conceptions of this disorder. We understand what we are talking about and, since we do, I think no additional change in the name of the disease is advisable at this time.

REMARKABLE EXTRAPYRAMIDAL INVOLUNTARY MOVEMENTS

A SPINAL FLEXION-EXTENSION AND A MESENCEPHALIC PROGRESSION REFLEX *

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AND

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In the past two years we have had occasion to study a series of cases exhibiting remarkable, and in some instances unique, involuntary movements. This report is concerned with these hitherto undescribed cases, and with certain physiologic speculations arising from their analysis.

Involuntary movements have an especial importance because of their relationship to the extrapyramidal system. Ability to interpret and to classify them has developed with understanding of that system, especially of the basal ganglia. We would draw attention to types of dyskinesia, their distribution and accompaniments, and especially to the seeming confirmation in man of observations made on the experimental animal. We present three groups of cases, each with two illustrations. Group 1 demonstrates one rare type of this condition, and a segmental dystonia of unusual localization and limitation; group 2 embraces two cases illustrating unusual types of choreiform movements of the Huntington type, and group 3 illustrates progression movements—originating in one case, presumably, in an extrapyramidal mechanism expressed in a spinal cord pattern, and in the other case in the midbrain mechanism, the clinical picture resembling the mesencephalic reflexes induced by Graham Brown in the experimental animal.

REPORT OF CASES

CASE 1.—*Torticollis-dystonia of segmental character in an elderly man, due to probable involvement of the basal ganglia.*

F. C., an Italian, aged 60, with unimportant past history and family history, became ill in June, 1924, with pain in the lower part of the back and an inclination of the head and trunk to the right; the head began to be drawn to the right. One

* Submitted for publication, Jan. 2, 1929.

* From the Department of Neurology, Montefiore Hospital.

* Read at the Fifty-Fourth Annual Meeting of the American Neurological Association, May 1, 1928, Washington, D. C.

year later, the movement had become constant. Early in 1927, facial grimacing and involuntary closure of the lower jaw appeared. The condition has remained stationary.

Physical Examination.—Study disclosed an interrupted, rotary, tonic-clonic movement of the head, with rotation of the occiput forward and to the right, and of the face and chin to the left. There was facial grimacing and involuntary closure of the lower jaw. The right shoulder was elevated; the right abdominal muscles were rigid, bringing the right hypochondriac region nearer to the right iliac crest. During the movements, the muscles of the parts affected were hypertonic, and following the movements they were hypotonic. The patient's effort at voluntary correction brought the left upper extremity into action for that purpose.

As having an etiologic bearing on the case, mention may be made of some inequality of the pupils, the left being larger than the right, and the sluggish reaction of both pupils to light. Wassermann tests of the blood and spinal fluid were negative, but in the latter the cellular elements were increased to the extent of 14 cells to the field. There were arthritic changes in the vertebral column with calcification of some of the lateral ligaments. The x-ray picture was one of hypertrophic spondylitis; it probably has no relationship to the involuntary movements.

Comment.—Except for the presence of fourteen cells in the spinal fluid, there is no evidence of an inflammatory process in the nervous system. The changes are probably due to cerebral arteriosclerosis with involvement of the basal ganglia. This case shows the dystonic syndrome in the partial or fragmentary form.[1] The resemblance of the syndrome to spasmodic torticollis makes the term "torticollis dystonia" appropriate.

In a review of the literature Lotmar [2] cited a number of instances of torticollis in which, later, the abnormal movements spread to involve the trunk and extremities; the reverse has been described, namely, torticollis as the residual of an extensive widespread hyperkinesis which regressed. André Thévenard [3] considered torticollis as a localized dystonia; the spasmodic variety as related to dystonia proper, the clonic variety to athetosis. In the pathologic studies of Tretiakoff, Cassirer and Bielschowsky, and Jakob, the organicity of these cases has been proved.

CASE 2.—*Atypical dystonia musculorum deformans in which the involuntary movements and posture are induced almost solely by voluntary effort.*—The symptoms are largely confined to the lower extremities. The neurologic signs bespeak scattered lesions of obscure etiology.

E. S., a man, aged 24, an American-born Jew, was first observed in 1925, and then three years later, in 1928. The past history was irrelevant. In 1916, at the age of 12, the patient first noticed tremor in the fingers of the right hand, which

1. Wechsler, I. S., and Brock, S.: Dystonia musculorum deformans, Arch. Neurol. & Psychiat. **8**:538 (Nov.) 1922.

2. Lotmar, F.: Die Stammganglien und die extrapyramidal motorischen Syndrome, Berlin, Julius Springer, 1926.

3. Thévenard, A.: Les dystonies d'attitudes, Paris, 1926.

made writing difficult. About six months later, choreiform movements appeared in the left leg. In 1918, the patient became ill with influenza, which lasted six weeks. The movements of the left lower extremity lessened, but the leg was dragged, and walking became difficult. Periods of decided improvement occurred. In 1922, he was still able to run and do ordinary gymnasium work; then the right lower extremity became involved, so that it was "thrown outward" in walking. By 1923, locomotion was disturbed. In the period from June, 1924, to March, 1925, some improvement was reported; later there was a relapse. The patient then complained of cramps and also of tremors in the right lower extremity. He was first observed from June to September, 1925. He then went abroad and was not seen again until November, 1928. The following is the most recent neurologic status (November, 1928). It differs so little from the studies made in the summer of 1925, that the few differences will be merely alluded to.

Neurologic Examination.—The gait was bizarre, due to the occurrence of tonic spasms in the quadriceps extensors, abductors and external rotators of the thighs, more especially of the right. It was at times reminiscent of the movements seen in Huntington's chorea. The right lower extremity was thrown outward, and externally rotated with the knee joint stiffly extended. With the outward thrust, the toes of the right foot, especially the big toe, dorsiflexed so that the foot was set down somewhat on the heel. (In 1925, there was hyperflexion at the joints of the right knee and hip, with a peculiar bowing over of the body toward that side in gait.) There was a definite twist of the pelvis, with elevation of the right hip. The left lower extremity was first rotated externally and then slightly rotated internally, with a tendency toward eversion of the foot. Both knees exhibited genu recurvatum. The right upper extremity swung freely; the left less so. The patient walked backward much better than forward, owing to the fact that the hamstring muscles which initiate stepping backward were practically uninvolved in the spasmadoc contractions.

On standing, spasm of both quadriceps extensors was noted. Occasionally there was external rotation of the left thigh with projection of the glutei on the outer aspect of the left buttock. At times these tonic contractions also occurred in the muscles of the back of the thigh. The spasms occurred mainly in the quadriceps and glutei, in the dorsiflexors of the right toes, and to a lesser extent in those on the left. The spasm of the quadriceps produced bilateral genu recurvatum. Some of these spasms were painful, others not. There was little tortipelvis and no myostatic postural fixation.[1] Except for an infrequent, slight spasm in the left triceps, the trunk, neck and upper extremities were not involved.

On sitting, a few involuntary movements were to be seen, of which the main one was a tremorlike external and internal rotating movement of the left thigh, on which was superimposed at times a larger spasm of the abductor (gluteus maximus). Crossing the left knee over the right caused it to disappear; this is the position of election.

On recumbency, the same features were noted as in sitting. The left lower extremity was rotated outward. A general hypotonus was noted. When the patient was relaxed, it was possible to elicit the tonic spasm in the quadriceps and other muscles by passive overflexion of the joints of the lower extremities. Under these circumstances, the hypertonus-hypotonus changes seen in dystonia were elicited.

The patient ran better than he walked. There was, however, a peculiar overflexion of the legs on the thighs, especially on the right; both feet tended to become everted.

The fundi and the fields of vision were normal. The pupils were equal and reacted well to light and in accommodation. There was a slight, questionable

ptosis of the right eyelid. There were distinct nystagmoid movements on extreme lateral gaze. On previous examinations, this had amounted to actual nystagmus in lateral and vertical directions. The external ocular movements were normal. There was no strabismus or diplopia, but at times there was a slight tendency of the right eye to turn inward. The functions of the fifth nerve were performed normally. The corneal reflexes were active. There was facial asymmetry, but no paralysis. Hearing was normal. The movements of the palate, tongue, trapezii and sternocleidomastoid muscles were normal. Speech was not affected.

The outstretched right hand revealed a Parkinson-like tremor, which was more evident when the palms face each other. At times a parkinsonian cupping of the right hand was apparent. The same hand showed a tendency to overpronation when the upper limbs were stretched upward. There was no atrophy and no paresis, and the reflexes were normal.

The abdominal and cremasteric reflexes were lively and equal.

There was no paresis or atrophy in the lower limbs. The knee jerks were present, but somewhat diminished. In 1925, a distinct pendular element was noted in both knee jerks, especially in the right. In 1928 the ankle jerks were active and equal. There was no Babinski reflex.

There was no ataxia on the finger-to-nose or heel-to-knee tests, and no adiadokokinesis. A slight rebound phenomenon was noted in the left upper extremity. There was no dysmetria. When the eyes were closed, the outstretched right hand sank a little. There was no past-pointing. Sensation was everywhere intact.

This patient was unusually intelligent and is now studying for a Ph.D. degree, having obtained an M.A. degree from Columbia University. He is, however, definitely euphoric and, at times, loquacious.

General Examination.—Except for a depressed pigeon-breast deformity of the sternum, the results of physical examination were entirely negative, as were also all laboratory observations.

Comment.—Case 2 presents dystonic, involuntary movements, largely confined to the lower extremities, and almost entirely elicited by other voluntary efforts, such as walking. Emotion increases their intensity. We cannot account for the remarkable restriction of the dystonic movements to volitional innervations definitely subserving other purposeful activities. In a large experience with dystonia musculorum deformans, we have never encountered this phenomenon before, nor are we aware of any description of such a case. In the present state of knowledge, it would be difficult to speculate on this point.

The Parkinson-like tremors of the right hand and left lower extremity, and nystagmus have been noted before in undoubted cases of dystonia musculorum deformans.[1]

The generalized hypotonia when the muscles are at rest, the previously observed pendular knee jerks, and possibly the genu recurvatum indicate the involvement of cerebellar pathways. The nystagmus also points to involvement of structures other than the basal ganglia. The pathologic process underlying this condition is obscure. However, the history of remissions, the nystagmus, the evidence of involvement of

the cerebellar pathway, and the evident euphoria, which is especially important, might well suggest an atypical multiple sclerosis.

CASE 3.—*Acute hemiballismus passing over into chronic hemichorea, on the basis of cerebral arteriosclerosis.*

M. M., aged 68, a cigar maker, was perfectly well until Feb. 20, 1928. While he was sitting in a chair, reading, the left arm suddenly began to move about violently and uncontrollably. After this time, the arm thrashed about incessantly. Soon the patient began to show some degree of emotional instability and also slight mental change. He was at no time unconscious.

Examination.—The patient showed slight "dancing" gait, limited to the left side. The left arm showed violent movements (hemiballismus), thrashing and revolving about to such an extent as to produce abrasions and contusions about the elbow. All the movements were much accentuated on emotional stimulation. All deep and superficial reflexes were present and equal; there were no paralyses and no sensory disturbances; the pupils were small, slightly irregular, reacted poorly to light and in accommodation (arteriosclerotic); the fundi showed arteriosclerotic vessels and the fields seemed to be contracted, possibly hemianopically on the left. The patient showed euphoria, volubility of speech and lack of power of concentration. The Wassermann reactions of the blood and spinal fluid were negative. The urine showed a trace of albumin, and the blood pressure was 180 systolic and 110 diastolic. The patient soon began to improve, so that the movements in the left arm became less violent, resembling more those of chorea. Occasionally, facial grimaces were noticed; these, together with the "dancing" clownish gait, all more or less limited to the left side, gave the appearance of a chronic degenerative hemichorea, clinically resembling the Huntington type.

The diagnosis was cerebral arteriosclerosis, acute hemiballismus on the basis of an hemorrhagic focus, probably in the subthalamic body of Luys (Jakob), with several scattered foci in various parts of the cerebrum (the basal ganglia and the hemispheres). The patient has continued to improve, but, in the main, still shows the hemichorea, especially in the left upper extremity.

Comment.—In a recent paper, Martin [4] described a case identical in character with ours, in which a hemorrhage had destroyed the contralateral corpus luysii. He reviewed thirteen other cases from the literature. In most of the cases, the large amplitude of the choreic movements was commented on. In the beginning of our case, the thrashing, whirling movement was of the type known as hemiballismus.

The acute onset of hemichorea with movements of large amplitude (hemiballismus) seems, therefore, referable in some instances to a lesion of the opposite corpus luysii. However, it is not known how such a destructive process permits this unusual hyperkinesis to come into being. As S. A. K. Wilson stated, one cannot ascribe an activity of this kind to destroyed cells.

CASE 4.—*Probable basal ganglion and cortical involvement (rheumatic encephalitis) following four attacks of acute rheumatic chorea, which resulted in a*

4. Martin, J. P.: Hemichorea Resulting from a Local Lesion of the Brain; Syndrome of the Body of Luys, Brain **50**:637, 1927.

clinical picture resembling chronic degenerative chorea. The psychic changes simulated those of dementia praecox.

H. C., a girl, aged 13, was admitted to Montefiore Hospital on July 12, 1927. The family history was without significance except that the mother was neurotic. The past history was irrelevant. In 1923, the patient had double pneumonia. After recovery, the gait became unsteady; she fell easily, often bruising herself; she was emotional and cried on the least provocation. The mother stated that the speech was disturbed, in that the patient pronounced certain words with difficulty. At times, trembling and other abnormal movements of the arms appeared. She was kept in bed for a number of months, with no improvement. At the Lenox Hill Hospital, in October, 1923, a diagnosis of "chorea with heart trouble" was made. She was then kept in bed for six months and discharged as slightly improved. She was again hospitalized from October, 1924, to April, 1925, and was discharged as cured. About the summer of 1925, she was said to have become normal in every way. Several months later, a relapse occurred, all of the symptoms reappearing. Two more relapses brought her back to the hospital from July to September, 1926, and from January, 1927, to July, 1927, at which time she was received at the Montefiore Hospital. This is the last of four attacks.

Physical Examination.—There was an enlarged heart with a mitral valve lesion. Fluoroscopy showed a rounding and prominence of the left ventricle. The lungs were normal. The red blood cells numbered 3,400,000; the hemoglobin measured 80 per cent, and the white blood cells numbered 8,500, with a normal differential count. The blood chemistry was normal except that the blood calcium was high—10.3 mg. per hundred cubic centimeters. The Wassermann reaction of the blood was negative. Examinations of the urine gave negative results.

In February, 1928, the patient had a typical attack of acute rheumatic polyarthritis.

Neuropsychiatric Examination.—On Nov. 21, 1927, study showed a number of important changes: The movements of the fingers, toes, hands and feet were largely choreiform, flinglike and purposeless. The left big toe was often hyperextended. The patient showed some parakinetic phenomena, that is, purposeful, patterned gestures, of remonstrance, for example, clumsily performed.

There were some dystonic features in the movements of the right upper extremity, and occasional athetoid movements in the fingers and toes. There was no postural fixation. The right upper extremity was apt to curl up in a circular fashion with flexion occurring at all the joints except the phalangeal, which were extended. Tonus was largely diminished everywhere, with an occasional involuntary hypertonic interruption. The deep reflexes were exaggerated; there was ankle clonus on the left. There was no Babinski toe sign. The abdominal reflexes were active and equal. The cranial nerves, coordination, in the strict sense, and sensation were normal.

The mental state was a combination of pliable negativism and heightened lability of mood; now resentful, now laughing and cooperative. Speech was reduced, and the occasional word was slowly expressed and monotonous.

Comment.—In a monograph, Lotmar [2] mentioned the instances of Bielschowsky, and of Urechia and Malescu. These, likewise, were juvenile cases of nonhereditary chronic degenerative chorea with psychic deterioration, which terminated in general muscular rigidity. The case described by Urechia and Malescu began with chorea followed by athetoid movements and lastly by rigidity.

Rarely, indeed, does acute chorea of the rheumatic type (Sydenham) result in a clinical picture simulating chronic degenerative chorea with mental changes. The secondary anemia, the cardiac valvular disease, and the attack of acute rheumatic fever observed by us point definitely to the latter infection. The four attacks of acute chorea must be regarded as rheumatic in origin. They seem to have resulted in a subacute or chronic rheumatic encephalitis. The French regard acute chorea as a kind of encephalitis, or the result of minute mycotic emboli. It is possible that in our case such a pathologic process occurred. The widespread nature of the lesions of chronic epidemic encephalitis is well known. There seem to be valid reasons favoring a somewhat similar pathology as a consequence of rheumatic infection.

We would attribute the mental changes to cortical involvement, and the involuntary movements to striatal implication.

CASE 5.—*Subacute combined degeneration due to pernicious anemia (or syphilis?) exhibiting a flexion-extension reflex of spinal automatism spontaneously and following stimulation.*

C. S., a man, aged 65, became ill in April, 1926, with a numb, "creeping" sensation in the fingers. One month later, generalized weakness, more marked in the extremities, appeared. An occasional sharp, shooting, shocklike sensation radiated from the back down into the lower extremities. Three months after the onset, walking became increasingly difficult. He became bedridden. Involuntary movements of the lower extremities, consisting of flexion at the hips, knees and ankles, appeared two months after the onset of the condition. They were associated with shooting pains down the lower extremities. No history of a sore mouth or tongue was elicited. Occasional eructation of gas after eating, a sense of fulness and pain in the epigastrium and chronic constipation with occasional diarrhea were the gastro-intestinal symptoms. There was no incontinence of urine or feces.

At the Lenox Hill and Presbyterian Hospitals in New York, at which the patient stayed for five months, a positive diagnosis of pernicious anemia with involvement of the cord was made. The patient was given three blood transfusions, and a liver diet was administered.

Physical Examination.—The man was bedridden with bilateral arcus senilis and marked pyorrhea alveolaris. The chest was emphysematous. The heart rate was 48 to the minute; the blood pressure, 140 systolic and 90 diastolic, and the electrocardiogram revealed an auricular premature beat. There were suspicious scars over the anterior surfaces of both legs.

Neurologic Examination.—There was a spastic paraplegia. Slight power of flexion at the larger joints was retained in the right lower extremity. Both lower extremities were extended and rigid and showed spasm of the adductors. There was an involuntary movement of both lower extremities, consisting of flexion at the knee, hip and ankle. This "flexion-reflex" occurred either on one side alone or on both sides simultaneously. When unilateral, the opposite extremity extended producing the pattern of walking; when bilateral, it was followed by an involuntary extension which was as important a feature of this cycle of automatism as the flexion. The patient complained of a shocklike sensation radiating down the lower extremities at the time of the involuntary movements. The latter had produced excoriation of the heels and of the internal malleoli. This reflex appeared spontaneously following stimulation of the soles.

Reflexes: The deep reflexes of the upper and lower extremities were equal and exaggerated. There was a bilateral Hoffmann sign and a Babinski toe phenomenon. The abdominal and cremasteric reflexes were absent.

Sensation: Vibration was impaired in both legs up to the knees. Position and joint sense was lost in both lower extremities at all the joints and was diminished in the fingers. Touch was lost from the fifth lumbar level downward. Sensation of pain was diminished over the fourth and fifth lumbar and first sacral segments.

There was ataxia in the upper and lower extremities, with slight dysmetria. Except for slight deviation of the jaw and of the tongue to the left, the functions of the cerebral nerves were normal.

Laboratory Tests: The blood picture was typical of pernicious anemia; there were absence of free hydrochloric acid in the gastric juice and a four plus Wassermann reaction of the blood and spinal fluid. The gum mastic curve with the spinal fluid was 34232200. The Queckenstedt test revealed no block.

Comment.—We would comment on the extreme rarity of this spontaneous flexion-extension reflex in cases of subacute combined sclerosis. The flexion-extension reflex is evidently a spinal cord phenomenon. Taking into account Graham Brown's experiments,[5] the studies of Kraus and Rabiner,[6] and our comments on case 6, we would interpret this phasic flexion-extension as originating in, or released by an extrapyramidal mechanism of the higher brain stem, though expressed in terms of a spinal cord pattern. This reflex may well represent a fundamental climbing movement, perhaps related to a phylogenetic arboreal stage.

The question arises further whether an extrapyramidal mechanism released from pyramidal control can express itself in a spinal flexion-extension reflex. We may assume here that interruption of the pyramidal pathway at the spinal cord level permitted the uninhibited intact functioning extrapyramidal tract to show this unusual manifestation. Obviously, such a dissociation is rare and is possible especially in a disease with a selective "funicular myelitic" pathology, as found in subacute combined sclerosis. We believe that the pyramidal lesion at the spinal cord level is responsible for the release of an older extrapyramidal reflex which originates higher up in the brain stem. The importance of the brain stem, especially the midbrain, in respect to standing and righting (Magnus and de Kleijn) leads us to believe that the reflex originates in this part of the nervous system, though expressed below in terms of a spinal pattern.

CASE 6.—*Acute epidemic encephalitis showing "progression movements" of the left upper and right lower extremities comparable to those induced by Graham Brown in experimental animals.*

5. Brown, Graham, quoted from S. A. K. Wilson: On Decerebrate Rigidity in Man and the Occurrence of Tonic Fits, Brain **43**: 220, 1920.

6. Kraus, W. M., and Rabiner, A.: On the Production of Neuromuscular Patterns by Release of Spinal Integration After Decerebration, J. Neurol. & Psychopath. **3**:209, 1922.

E. C.,[7] aged 6, was well until Dec. 1, 1927, when, apparently without cause, he fell against a stove, striking the back of his head. He seemed to show no ill effects for a few days. Then it was noticed that he staggered and tended to fall to the right. At the same time, he began to have twitchings of the left upper extremity, which recurred every few minutes. The child did not appear ill otherwise; it was not noted whether he had fever. The past history is irrelevant.

Examination.—At the hospital, the boy had a staggering gait with a tendency to fall to the right. He had slight tremor of the left hand and marked tremor of the right hand. Every minute or two there occurred spontaneously a sudden convulsive flexion movement of the left arm at the elbow and a protraction and adduction at the shoulder. All the reflexes were normal; there was no ataxia, motor palsy or sensory disturbance. The pupils reacted promptly; there was some question of ptosis of the left eye and facial weakness on the right. The veins of both fundi seemed full, and the margins of the right disk appeared blurred. The other cerebral nerves were normal. The possibility of hemorrhage or, more remotely, neoplasm (tuberculoma) was entertained at the first examination.

Course.—From the time of admission, the boy ran a low grade fever (up to 101 F. or slightly over). He gradually grew worse, speech became somewhat halting, and later the power of speech was lost, though he was neither mute nor aphasic. He had a tendency to fall to the right on sitting up, and he usually lay on his right side. In addition to the sudden jerking flexion movements of the left upper extremity, he soon developed an equally sudden and synchronous crossed flexion movement of the opposite lower extremity. The tremor, which seemed to be typically mesencephalic (red nucleus?) in character, became more marked. The rest of the neurologic examination was unchanged.

The low grade fever persisted, the pulse varied and the crossed flexion movements continued, but hypotonia was now present in the lower extremities. X-ray examination of the skull gave negative results. Several spinal punctures showed no increase in cells, and the serology was normal. After a few weeks the condition was the same, except that the crossed movements appeared like waves of decerebration, with this difference that the left arm was flexed instead of extended, and the right lower extremity extended at the knee but flexed at the hip. The movements gradually became more violent, and at times the right upper and left lower extremities were also involved to a slight extent. The boy began to drool saliva. He became incontinent, but whether due to dulness or not could not be determined. A diagnosis of epidemic encephalitis was now definitely made.

About a month after admission, conjugate deviation of the eyes to the right was noticed. The crossed flexion movements became less marked. The boy grew duller. The movements became less violent; facial grimacing was occasionally observed, the extremities became somewhat hypertonic, and articulation, if anything, more restricted. The boy lay usually on one side, more often the right, and twitchings occurred as a rule only on sudden stimulation. At all times these movements were intensified by emotion, manipulation or stimulation; sometimes they were brought about by sudden flexion of the head forward. The boy has lingered on for several months, and now seems to be entering a hypokinetic chronic encephalitic state.

Comment.—Case 6 presented several important features. The question of trauma and possibly hemorrhage of the brain was at first seriously considered; also the possibility of posterior fossa neoplasm and

7. This patient was in the pediatric service of Dr. E. A. Riesenfeld, the Sydenham Hospital, New York.

tuberculoma of the midbrain; and, finally, possible epidemic encephalitis and mesencephalic lesion of exquisite localization. Of greatest interest, however, was the crossed flexion of the extremities, simulating, as it were, waves of decerebration. This is undoubtedly an extremely rare manifestation, and resembles the results obtained by Graham Brown with experimental stimulation of the midbrain.

According to Graham Brown,[5] electrical stimulation applied to the cross-section of the midbrain of the monkey at the level of the anterior corpora quadrigemina, in the region of the red nucleus and posterior longitudinal bundle, produces a characteristic response. Unilateral stimulation evokes a state of flexion in the ipsilateral arm and extension in the contralateral arm. "On cessation of the stimulation, these reactions are continued as maintained postures." In addition, "the lower limb of the same side extends while that of the opposite flexes; the head is rotated in such a manner that the face is turned away from the side stimulated." Mutual antagonism of the right and left focal points was demonstrated. "Immediate or successive compounding of the two stimuli, produced bilateral extension, bilateral flexion, and so on. With varying values of stimulation, varying values of contralateral extension and ipsilateral flexion might compound, to give reaction in which extension and flexion exhibited differing preponderances."

In this case the manifestations warrant a discussion and speculation as to their ultimate genesis. Here, some of the signs (ptosis, tremor) point to the midbrain. In addition, Graham Brown's experiments on animals focus attention on the red nucleus. With the latter's work in mind, we would interpret this case as a clinical confirmation of the Graham Brown experiment on animals relating to the functions of the red nucleus. This phasic reflex may be regarded as a fragment of walking, induced by an irritative process acting on the red nucleus.

Such a conception of this involuntary crossed movement would attribute it to stimuli carried from the midbrain to the anterior horn cells, again along extrapyramidal pathways (rubrospinal or tectospinal?). Though more rapid than the flexion-extension reflex considered in case 5, this movement also depends on intact extrapyramidal pathways.

CONCLUSIONS

1. A series of unusual dyskinesias is presented, including an instance of hemiballismus, two cases each presenting unique dystonic syndromes, and a juvenile case of chronic degenerative chorea, with mental changes, on the basis of rheumatic encephalitis.

2. A flexion-extension reflex is described in a case of funicular degeneration (subacute combined sclerosis). The movement is believed to be due to the action of an extrapyramidal mechanism released by a diseased pyramidal tract.

3. A crossed progression movement involving the left upper and the right lower extremities is analyzed. By comparison with the experiments of Graham Brown on animals, reasons are adduced for regarding the movement as due to the stimulation of mesencephalospinal (extrapyramidal) pathways.

4. The occurrence of the spontaneous flexion reflex herein described, and the explanation adduced, raise the question whether the marked flexion spasm in cases of chronic dystonia musculorum deformans may not be due to similar midbrain mechanisms. Despite the fact that the pathologic process in dystonia occurs preponderatingly in the basal ganglia, the dissemination of the pathologic processes in various parts of the brain permits the inference that in this disease, too, mesencephalic mechanisms are involved.

THE BEHAVIOR OF CERTAIN LIPOIDS DURING THE PROCESS OF MYELINOGENY

A MICROCHEMICAL INVESTIGATION *

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The study of myelin dates from the introduction of Carl Weigert's staining method,[1] in 1884, but its composition is still a matter of considerable obscurity, and ignorance is almost complete concerning the manner of its deposition and its chemical synthesis. Its origin from the blood would seem to be a fairly sound postulate, but little if anything can be stated concerning the physical or chemical mechanism by which the ingredients are assembled.

The term myelin is applied by morphologists to the lipins that form the medullary sheaths of nerves; by chemists it is restricted to fat-like substances which originate within necrotic cells in the living body.[2] As a generalization, one might say that there is evidence to indicate that myelin consists of cholesterol; cholesterol esters; glycolipins or cerebrosides, consisting of fatty acids with nitrogen and a carbohydrate group; phospholipins or phosphatides, consisting of fatty acids with nitrogen and phosphorus; glycophospholipins or phosphorized cerebrosides which are combinations of glycolipins or phospholipins; glycophosphosulpholipins, a more complex compound with a sulphur molecule added, and perhaps inorganic salts.

Other substances, such as protagon, first isolated by Liebreich,[3] and lipochrome or lipofuchsin are spoken of. The first was believed by Liebreich to dissociate into lecithin and choline or neurine oleate. Physiologic chemists, however, are not in agreement that it exists as a chemical entity but consider it to be a mixture of glycolipins and phospholipins. Lipochrome and lipofuchsin are names applied to a

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1. Weigert, Carl: Fortschr. d. Med. **2**:120, 1884.

2. Mallory, F. B., and Wright, L. H.: Pathological Technique, Philadelphia, W. B. Saunders Company, 1924, p. 189.

3. Liebreich, O.: Ueber die Entstehung des Myelinformen, Arch. f. path. Anat. **32**:387, 1865.

substance believed to contain fats with carotin dissolved in them.[3] There is the same uncertainty concerning the chemical identity of this substance as in the case of protagon.

According to Cramer and Lee,[4] the term fatty substances includes true fats and lipoids. True fats are esters of the alcohol, glycerol, in combination with the higher fatty acids which may be saturated, as palmitic and stearic, or unsaturated, as oleic. The term lipoids was used originally to denote substances having solubilities similar to those of true fats. The term is now restricted to cholesterol and its esters, phosphatides (phospholipins), cerebrosides (glycolipins), phosphorized cerebrosides (glycophospholipins), and a combination of phosphorized cerebrosides with a sulphur group (glycophosphosulpholipins).

The investigations of Wlassak,[5] in 1898, on the microchemistry of myelin were the most complete up to that time. He concluded that myelin consisted of fat, lecithin and protagon, and that in early embryonic life its situation was in the protoplasm of the spongioblasts and the epithelial cells of the roof plate of the third and fourth ventricles. He believed that the accumulation by the ependymal cells subsided after vascularization, and that the myelin was situated principally around the blood vessels from which it shifted to the periaxonal position that it occupies during adult life, forming the sheathing substance for the axon.

An observation previously made by one of us (L. H. C.[6]) gives some confirmation to this view in certain of its aspects. In prenatal and early postnatal rats globular bodies were observed in the spaces of the pia-arachnoid. By the methods customarily employed for the demonstration of myelin sheaths, these bodies were well stained in some instances, while in others they failed to stain and appeared as mere skeleton forms. The size of these globules was extremely variable. Some were about the size of red blood cells, and others were several times this size. These globular forms were identified in sections from fifteen different animals, ranging in age from prenatal to 3½ days.

During the first few days of postnatal life these globular elements were seen at the periphery of the axis and, in some sections, the appearance suggested an invasion of the axis from without. The first thought was that these forms might be red blood cells that had become extravasated during the removal of the brains. The technic, however, was a simple one, and this possibility seemed remote. All of the animals had

4. Cramer, W., and Lee, J. B.: The Microtomist's Vade-Mecum, Philadelphia, P. Blakiston's Son & Company, 1924, p. 356.

5. Wlassak, R.: Die Herkunft des Myelins, Beitr. z. Physiol. d. Nerv. Stutzgew. **6**:453, 1898.

6. Cornwall, L. H.: The Origin of Myelin, Arch. Neurol. & Psychiat. **18**: 240 (Aug.) 1927.

been killed with ether; the delicate osseocartilaginous structures of the calvarium were cut away, and the brains were freed carefully with fine scissors and then dropped into bottles containing the fixatives. In order to control this feature of the technic, we exsanguinated several animals by severing the jugular veins before removal of the brains. The same elements were visible after this procedure which warrants the conclusion that they were not mere extravasations.

EFFECT OF CHROMATING

In 1909, Smith and Mair [7] investigated the Weigert method, in a manner similar to Wlassak, by applying it to artificial sections of known chemical composition. The substances investigated were smeared on cigaret papers and then exposed to the action of bichromate solution. These experimenters found that by exposing fatty tissues to solutions of potassium bichromate that were saturated at 37 C. or by more prolonged action of a weaker solution the chromium oxide would combine with the fat and render it stainable by the Weigert method. Certain of the fats and fatty acids that could be stained after exposure to concentrated bichromate solutions for specific periods lost this affinity for hematoxylin after more prolonged exposure. This was explained as due to complete oxidation of the unsaturated organic compounds either into substances incapable of forming a chromium lake with hematoxylin or into chromium salts which are soluble in water and therefore removed by the solvent.

Triolein, when mordanted at 37 C., stained slightly after four days, clearly after five days, still clear after twenty-four days, but after seven weeks the smaller globules ceased to stain. At 65 C. there was clear staining after one day, less clear after five days and none at all after twenty days. Oleic acid gave similar results. Triolein and cholesterol stained faintly after two days, clearly after three days and still clearly after twenty-four days. Oleic acid and cholesterol stained clearly after one day, still clearly after three days, faintly after ten days and not at all at twenty-four days. Pure cholesterol, cholesteryl oleate, elaidic acid, lauric acid, palmitic acid, caproic acid, caproic acid and cholesterol, and cholesteryl palmitate were unstained after periods of mordanting varying from fourteen to twenty-three days.

Smith and Mair concluded that, in the case of fats and fatty acids, staining is obtained by the Weigert method only when the substance contains an unsaturated grouping, and that the process of bichromating is one of oxidation as a result of which the myelin sheath stains first, then the lipochrome of the nerve cells, then the nucleoli and finally, when

7. Smith, J. L., and Mair, W.: An Investigation of the Principles Underlying Weigert's Method of Staining Medullated Nerve, J. Path. & Bact. **13**:14, 1909.

the myelin sheaths are no longer chromophilic, the axis cylinders are stained clearly. Prolonged mordanting, then, reverses the Weigert picture and, if carried to the stage of "over oxidation," results in complete chromophobism.

With our usual method of preparing tissues for the demonstration of myelin, employing Mueller's fluid at room temperature for the primary mordant, 5 per cent copper bichromate for the secondary mordant, and the Kulschitsky-Pal stain, we were not able to produce any differences in the stainability of the nerve tissue of rats at birth after mordanting for periods of three, four and a half, ten and twenty-four days. We would conclude, therefore, that triolein and oleic acid, either alone or in combination with cholesterol cannot be demonstrated as precursors of myelin.

OSMIC ACID REDUCTION

Staining with osmic acid also depends on the presence of an unsaturated grouping. Without exposure first to potassium bichromate, osmic acid is quickly reduced and stains the myelin sheath gray-black. According to Lee,[8] if tissues are treated with osmic acid without preliminary chromating, the true fats and lipoids are all more or less easily oxidized, and therefore they are blackened by the reduction of osmic acid to a lower oxide. The rapidity of this reaction varies with the different lipoidal radicals. Fats are affected first, then phospholipins, cholesterol, glycolipins and phosphoglycolipins. Preliminary chromating prevents the osmic acid from being reduced by any substances except those possessing the strongest reducing power, such as true fats and mixtures of cholesterol and unsaturated fatty acids.

Pieces of brain and cord tissue from rats at the prenatal period, at birth, at 1 day, at 3 days and at 8 days were treated with 1 per cent osmic acid both before and after exposure to the action of Mueller's fluid. As palmitic and stearic compounds are stained only when alcohol follows the exposure to osmic acid, some sections were treated in this manner. The results were entirely negative in the prenatal, birth and 1 day animals. In the rats 3 and 8 days old the few fiber systems that were myelinized stained slightly when preliminary chromating was omitted, as one would expect. None of the compounds enumerated as stainable with osmic acid were demonstrated by us as constituents of the neuraxis previous to the appearance of myelin.

LIPOID SOLVENTS

The evidence indicates that there are differences in the solubilities of the various lipoid radicals. The solvents usually employed consist of acetone, alcohol, chloroform, ether, methyl alcohol and chloroform,

8. Lee, J. B.: The Microtomist's Vade-Mecum, Philadelphia, P. Blakiston's Son & Company, 1924, p. 359.

acidified alcohol and ether, benzene, xylene and petroleum. We have employed all but the last three of these solvents.

Acetone, alcohol and chloroform were employed first in the belief that acetone was best suited to remove true fats and cholesterol fatty-acid mixtures; that alcohol would remove phospholipins in addition, and that chloroform would remove cholesterol esters and glycolipins in addition to the alcohol-soluble radicals. Frozen sections of brains of rats fixed in formaldehyde at the prenatal period, at birth, at 3 days and 8 days were immersed in these solvents for twenty-four hours and then stained with scharlach R alone and with the addition of hematoxylin. Other sections were stained directly from 10 per cent solution of liquor formaldehydi for comparison.

No specific staining reactions could be detected in the ectodermal structures of the neuraxis either before or after the use of these solvents. In the prenatal animals some of the contents of the blood vessels, especially in the choroid plexus, stained red to reddish yellow with scharlach R. After the application of acetone and alcohol, this coloring persisted but was removed entirely by chloroform. This indicates that the blood of prenatal animals contains some lipoidal substance or substances that can be removed by chloroform but not by acetone or alcohol. These solubility reactions correspond to cholesterol esters and glycolipins.

Ciaccio[9] stated the belief that saturated fatty acids, cerebrosides and lipochrome can be stained by scharlach R after treatment with saturated zinc acetate. These substances are insoluble in alcohol after this treatment, but the cerebrosides may be removed by equal parts of methyl alcohol and chloroform and the saturated fatty acids by equal parts of acidified alcohol and ether. The lipochrome is not removed even by hot xylene. In combination with protein, however, lipochrome does not stain with scharlach R. This method was applied to the brains of rats from the prenatal period up to 8 days, and the results were entirely negative.

FATTY ACID STAINS

Fischler[10] and Fischer[11] have shown that if tissues are placed in copper acetate when fresh, the fatty acid compounds are converted into insoluble copper soaps that will stain with hematoxylin. Immersion in an aqueous fixative before the copper will cause a loss of some of the soluble soaps. If fixation is with 10 per cent solution of liquor formaldehydi which has been saturated with calcium salicylate, insoluble calcium soaps are formed.

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9. Ciaccio: Arch. f. Zellforsch. **5**:235, 1910; Pathologica **13**:183, 1921.
10. Fischler: Ztschr. f. wissensch. Mikr. **22**:263, 1905.
11. Fischer: Centralbl. f. allg. Path. u. path. Anat. **15**:913, 1904.

Klotz [12] has modified this method by substituting a saturated solution of hematoxylin in 60 per cent alcohol for the saturated absolute alcoholic solution of Fischer. In this way he avoided any disturbance of the neutral fats which can be stained subsequently by scharlach R or sudan III. If both hematoxylin and scharlach R are used, fatty acids are stained black, calcium soaps blue black and neutral fats red. Further treatment with silver nitrate will blacken the calcium salts and assist in their differentiation.

With both the Fischer method and the Klotz modification of it we have observed bluish stained fibrillar masses in several parts of the neuraxis of rats at birth. By modifying the technic of this method the whole axis may be stained diffusely or entirely decolorized, but, in our opinion, the areas that are occupied later by myelinized structures in the adult animal are more sensitive to the stain. The same extravascular globular masses previously noted were identified in the pia-arachnoidal spaces. Some of them were stained black, and others were entirely unstained.

With Nile blue sulphate, Lorrain Smith [13] has identified some of the lipoid fractions on the basis of their tinctorial reactions; neutral fats stain bright red, cholesterol esters and cholesterol-fatty acid mixtures reddish, glycolipins and phospholipins light bluish and fatty acids and soaps deep blue. The dye is employed in an aqueous solution; therefore, there is no danger of any loss of fatty substances.

In our hands the Nile blue sulphate stained the neuraxis diffusely blue at all ages up to 8 days. The fact that the same result was obtained with Klotz' method when decolorization was not carried too far suggests that fatty acids, and perhaps phospholipins and glycolipins, may be distributed diffusely throughout the neuraxis. This view is, in part at least, in accord with an observation of the Kochs,[14] that phospholipins are present before medullation and that they are in the cells as well as in the myelin sheaths.

Another dye that has affinity for lipoids is neutral red. It stains phospholipins, glycolipins, fatty acids and soaps. We were not able to detect any areas in the axis that exhibited especial affinity for this dye. At all periods from the prenatal to 8 days, the neuraxis was stained diffusely red. This result points to the same conclusion that was suggested from the observations with Nile blue sulphate.

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12. Klotz, O.: Studies upon Calcareous Degeneration, J. Exper. Med. **8**:322, 1906.

13. Smith, Lorrain: On the Simultaneous Staining of Neutral Fat and Fatty Acid by Oxazine Dyes, J. Path. & Bact. **12**:1, 1908.

14. Koch, W., and Koch, M. L.: The Chemical Differentiations of the Albino Rat During Growth, J. Biol. Chem. **15**:423, 1913.

GLYCOGEN

With Best's stain, glycogen was identified in the form of fine dust-like particles, medium sized granules and relatively large masses in the spaces of the pia-arachnoid, especially in the region of the metencephalon and in the choroid plexus of the fourth ventricle of rats at birth.

SUMMARY

1. Before and during the early stages of myelin formation in rats, there are globular elements in the ventricles, in the pia-arachnoidal spaces and in the periphery of the neuraxis. These forms either disappear or are obscured as the fiber systems become medullated. After exsanguination, by severance of the jugular veins, the same forms can be seen, indicating that they are not mere extravasations.

2. Mordanting with a saturated solution of potassium bichromate at 37 C., according to the method of Smith and Mair, has not shed any light on the chemical nature of these forms except in a negative sense. They do not consist of triolein, oleic acid or combinations of these fatty substances with cholesterol.

3. Osmic acid treatment of chromated and nonchromated tissue produced similar pictures but did not furnish any clue concerning the chemical identity of the globular forms previously mentioned or the chemical constitution of myelin in its earliest stage.

4. Scharlach R alone and in combination with hematoxylin gave no information concerning the lipoidal constitution of the neural ectoderm during the period of myelin development. When applied direct to tissues, fixed in formaldehyde, before and after the use of acetone, alcohol and chloroform as solvents, these stains showed that the blood vessels of the neuraxis contain lipoids that have an affinity for scharlach R, perhaps consisting of glycolipins and cholesterol esters.

5. Saturated fatty acids, glycolipins or lipochrome could not be identified in the neuraxis by the method of Ciaccio either before or during the process of myelin deposition.

6. By the methods of Fischler, Fischer and Klotz there is some evidence to indicate that the fiber systems contain calcium soaps before they receive their myelin and that before and during the medullation fatty acid can be identified in the blood vessels of the neuraxis and in the spaces of the pia-arachnoid.

7. A diffuse bluish staining of the neuraxis with Nile blue sulphate and a diffuse red staining with neutral red furnishes some evidence that fatty acids, glycolipins and phospholipins are distributed diffusely throughout the neuraxis of young rats but not limited to any one structural component.

8. The choroid plexus of the fourth ventricle and the pia-arachnoidal spaces of the brain of rats at birth contain glycogen. We do not know whether or not this persists throughout the life of the animals.

9. We have not been able to deduce any evidence that the complex chemical compound, which is designated as myelin, is formed by a gradual synthesis of simpler lipoids. So far as we have been able to observe, it makes its appearance in approximately the same state in which it exists throughout the life of the organism.

THE SPINO-ADDUCTOR REFLEX

A SPINOMUSCULAR PHENOMENON IN THE DISTRIBUTION OF THE LUMBAR SEGMENT AND THE ADDUCTORS OF THE THIGHS: A PRELIMINARY NOTE *

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The phenomenon which I shall discuss occurs as a normal reaction. It also occurs in a modified way in pathologic conditions of the spinal cord and possibly also in conditions of the cerebral tissue.

The phenomenon is elicited by having the patient in a sitting position with the spine curved forward. The knees are separated from each other about 6 inches (15.24 cm.). The legs are placed so as to rest on the floor at right angles to the thighs. The arms are dropped relaxed on either side of the legs.

The spine is not percussed directly with the percussion hammer. The index finger is placed firmly against the spine, in the median line, and a sharp blow is made against the finger.

In the normal person, if each successive segment of the spine is so percussed, at the level of the first lumbar spine and extending through the lumbar area, a sharp contraction of both adductors of the thighs results and an adductor movement of the knees is seen. There is a variation in normal persons. In those with quick, easily elicited tendon reflexes, this phenomenon may be present as high as the twelfth dorsal segment.

In pathologic conditions of the spinal cord, for example, in meningomyelitis, multiple sclerosis and progressive ascending pyramidal lesions, this phenomenon can be elicited from the sixth cervical segment throughout the dorsal and lumbar areas.

In tabes dorsalis, and at times in the parkinsonian syndrome, this phenomenon is entirely absent.

When one comes to analyze this phenomenon one meets with difficulty in finding any satisfying explanation of it.

My first impression was that I was dealing with a type of diffuse, bilateral girdle reflex of periosteal origin. With this idea in mind, I have, in cases in which the phenomenon was most marked, tried to elicit

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this phenomenon in the exposed bony areas of the pelvic girdles. Percussion over the sacrum, the crests of the ilia and the anterior superior process gives, however, negative results. The extension of the phenomenon in diseases of the spinal cord to such high levels as the cervical vertebrae would largely eliminate the reflex as an explanation.

Could the picture presented be the result of purely mechanical irritation transmitted to the anterior motor roots? The wide extension of the phenomenon to the upper levels of the spine eliminates this as an explanation.

It is possible that one is dealing here with a defensive reflex phenomenon. A sudden pressure blow on the spine would act as an acute overload on the spine of an animal on all fours. The defensive mechanism of this would be an effort to brace the support of the body by a reflex contraction of the supporting muscles. It is not easy to explain why the adductors alone would take part in this process. One would expect that all the muscles of the extremities would be involved, and not only the adductor groups. In support of this explanation is the absence of this phenomenon in the human being in the upright position, and, further, the fact that it is elicited only when the relation of the parts conform to that of the animal on all four extremities.

The remaining possible explanation would be a direct transmission of the shock vibration of the bones of the vertebra to the underlying segment of the spinal cord. If the phenomenon were limited to the underlying segment one could explain, by the effect of motor irritation on the peripheral motor mechanism, the motor reaction in the extremities. Here again, one is faced with the selective action in the motor response. It is not easy to explain why the motor neurons, cells or roots supplying the adductors should be involved, to the exclusion of the more important flexor and contractor groups.

Notwithstanding these objections, I am of the opinion that the phenomenon has its origin in the cord, and that the reaction is a response of the peripheral mechanism to a percussion irritation.

How is one to explain the cases in which this phenomenon can be elicited on percussion of the cervical, dorsal and lumbar spines?

The reason for this publication is the possible effect a study of this phenomenon might have on the knowledge of association paths in the spinal cord.

It is unthinkable that there should not be association paths or fibers linking the various vertebral segments to each other. There is, indeed, much evidence that there are not only short paths joining the contiguous segments one to another, but longer paths, joining the segments of the pelvis and of the shoulder girdle to a coordinating whole, independent of the cerebral mechanism.

Only on such an assumption can one explain the gradual extension upward of this phenomenon in various cases of sclerotic lesions of the spinal cord, and especially in those cases in which the shoulder girdle is involved. It is entirely consistent with this point of view that, in complete transverse lesions of the cord, this phenomenon is absent on percussion above the area of lesion.

My main purpose in publishing this preliminary note is to stimulate others to make a study of this phenomenon and to attempt a correlation of the clinical, pathologic and experimental studies.

I have not published my case studies, which cover a period of five years, on account of lack of autopsy material confirming or denying the clinical theoretical assumptions.

TRAUMATIC PARTIAL HEMISECTION OF THE SPINAL CORD

REPORT OF TWO CASES SHOWING MOTOR AND SENSORY CHANGES *

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Incomplete hemilateral injuries of the spinal cord in the cervical region, with the resulting sensory and motor manifestations, are uncommon, and most often are the result of indirect violence—fracture dislocation of the vertebrae. In the World War, shrapnel and sharp, irregular shell fragments sometimes caused traumatic partial hemisection of the spinal cord by direct violence. Both of these, however, rarely cause strictly unilateral lesions.

Stab wounds of the spinal cord are rare and give the most circumscribed and discrete lesions, and hence the most limited and definite sensory dissociation along with localized motor manifestations. The symptom-complex of partial hemisection differs from the Brown-Séquard syndrome of complete hemisection in that in the former the contralateral sensory loss is limited to pain and temperature senses, and there are no signs of disturbance of posterior column sensation. Hyperpathic sensation (heightened feeling tone), so well described by Foerster,[1] in which there is loss of pain and temperature sense on the side of the body opposite to the lesion, was clearly demonstrated in these cases.

The site of the lesions in these two cases is known accurately, and their nature limits the lesions to definite areas. These limitations are corroborated by the results of the examination made a few hours and also several months after the wounds were received.

Elsberg [2] stated that traumatic lesions may injure part of the cord and that portions of the fiber tracts or entire tracts may be divided with almost anatomic exactness, as in experiments.

Head [3] described several cases of traumatic lesions in a portion of one half the cervical cord. All these cases presented loss of pain and temperature sense on the side of the body opposite the lesion, and an upper motor neuron paralysis in the limbs on the same side as the

* Submitted for publication, Sept. 12, 1928.

* Read by title at the Fifty-Fourth Annual Meeting of the American Neurological Association, Washington, D. C., May, 1928.

1. Foerster, O.: Die Leitungsbahnen des Schmerzgefühls und die chirurgische Behandlung der Schmerzzustände, Berlin, Urban & Schwarzenberg, 1927.

2. Elsberg, Charles: Diseases of the Spinal Cord and Its Membranes, Philadelphia, W. B. Saunders Company, 1916, p. 232.

3. Head, Henry: Studies in Neurology, New York, Oxford University Press, 1920, vol. 2, pp. 410-428.

lesion. There were no other sensory changes. The exaggerated feeling tone in these cases was limited to the area of loss of pain and temperature sensibility. In one of Head's [4] cases the patient said that the strong interrupted electric current gave him exactly the same sensation as that produced by holding a hot plate. In other instances, the electrical stimulation was said to be disagreeable but not painful.

Head [5] also stated that stimulation with a strong interrupted current normally causes pain which, on rising to intolerable limits, obscures all other sensations. If the painful impulses are interrupted by an intramedullary lesion, the tactile element of this stimulus is appreciated and then, when the current is strengthened, the sensation produced is painless but intensely disagreeable. Thus at the second or medullary level, even the impulses of tactile sensibility subserve a discomforting sensation.

Stewart [6] stated that in areas of hypalgesia, pin prick may cause an itching feeling instead of pain.

Lloyd [7] published a report of two cases of traumatic lesion of the cervical region of the spinal cord with loss of pain and temperature senses on the side of the body opposite the lesion. In one of these cases, on the side of loss of pain and temperature senses the patient experienced a burning sensation, and although he wished constantly to put cold water on it to allay the heat, he found this remedy ineffectual.

REPORT OF CASES

CASE 1.—*History.*—N. M., aged 39, married, a housewife, who was born in Italy and had lived in New York City for twelve years, between 8 and 9 p. m. on March 21, 1927, while stooping over a sink was shot twice from a revolver held close to the left side of her body. She fell to the floor, but did not lose consciousness, and was taken to Harlem Hospital at 9 p. m. with the following complaints: pain in the left side of the neck and in the posterolateral region of the left thorax, at about the fifth and sixth thoracic dermatomes; weakness and much thirst. One thousand five hundred units of tetanus antitoxin were administered at that time.

Physical Examination.—The patient was well nourished; she was lying in a prone position. Blood was flowing from the left external auditory canal. About 1.5 cm. in front of the tragus of the left ear was a bullet wound of entrance. Behind the left ear, in the posterior cervical region, there was swelling and subcutaneous emphysema. The pupils were equal in size and regular in outline; they reacted to light and in accommodation. There was an ecchymosis

4. Head, Henry: Studies in Neurology, New York, Oxford University Press, 1920, vol. 2, p. 411.

5. Head, Henry: Studies in Neurology, New York, Oxford University Press, 1920, vol. 2, p. 406.

6. Stewart, Purves: The Diagnosis of Nervous Diseases, London, Edward Arnold, 1916, p. 201.

7. Lloyd, J. H.: A Study of the Lesions in a Case of Trauma of the Cervical Region of the Spinal Cord, Simulating Syringomyelia. Brain **21**:23, 1898.

of the left lower eyelid. There was a complete left facial paralysis and a subcutaneous emphysema of the left side of the face. The left palpebral fissure was larger than the right. On coughing, a thick, dark, blood-stained mucus was expectorated. There was a subcutaneous emphysema of the thorax, greater on the left than on the right side. The heart sounds were feebly heard. There was no displacement of the heart, but impaired resonance was present over the left lower lobe of the lung. Breath sounds and vocal fremitus were normal. There was a bullet wound of entrance about 5 cm. below the spine of the left scapula. The liver and spleen were not felt. There was no tenderness of the abdomen, and no masses were felt. The patellar reflexes were active and equal.

Course.—On March 25, 1927, the otologist reported a swelling and tenderness of the antitragus and mastoid regions on the left side. The ear canal was filled with fetid debris, and the drum was edematous and perforated. Hearing was greatly impaired on the left side.

On April 4, 1927, there was complaint of severe pain in the left mastoid region with posterior cervical stiffness. Operation was performed on the left mastoid on this day.

On April 29, 1927, for the purpose of localizing the position of the bullet in the neck, two needles, each about the size of a lumbar puncture needle, were inserted in the left posterior cervical region, one about 4 cm. and the other about 5 cm. to the left of the dorsal midline of the body, with the production of a sudden complete flaccid paralysis of the left arm and leg. A few hours later, an operation for the removal of the bullet was performed. An incision about 10 cm. long was made in the left posterior cervical region, the muscles were separated, and the bullet was located and removed. The wound was packed and then closed with interrupted silkworm gut sutures.

On April 30, 1927, a neurologic examination was requested.

Neurologic Examination.—The patient complained of inability to move the left arm and leg, and of a disagreeable sensation in the right side of the body.

The patient was a moderate drinker of tea, coffee and wine. Urination had been normal until the operation on April 29, 1927, since when there had been retention. The family history was irrelevant. There was a flattening of the left side of the face and a drooping of the left corner of the mouth, and the left palpebral fissure was wider than the right. She was unable to walk. Coordination was normal in the right upper and lower extremities. She was unable to move the left arm and leg.

All deep reflexes were lost on the left side of the body. All deep reflexes were active on the right side of the body, with the exception of the achilles reflex which was present. The superficial reflexes were diminished on the left side of the abdomen, but active on the right. There was bilateral plantar flexion.

She was unable to rise from a recumbent to a sitting position. There was complete flaccid paralysis and atony of the left arm and leg; the right arm and leg were normal.

Touch acuity, localization and discrimination were normal on both halves of the body. Pain sensibility was lost on the right side of the body from the second cervical dermatome downward. Pain sense was normal on the left side of the body. There was loss of heat and cold appreciation on the right side of the body below the second cervical dermatome.

Vibratory, pressure, muscle tendon, stereognosis and barognosis senses were normal throughout the body. Hyperpathic sense was revealed when the patient was given an alcohol sponge bath. When the left side of the body was sponged, there was a sense of comfort associated with a slight cooling effect, but when the

right side was sponged, the patient attempted to squirm away from the nurse and complained that the feeling was intensely disagreeable and uncomfortable.

The cranial nerves were normal, with the exception that the right pupil was 3 mm. and the left 1.5 mm. in diameter. The pupils were circular in outline, and their position was normal. The left pupil reacted to light with greater amplitude than the right pupil. There were a few nystagmoid movements to the left and right. The palpebral fissures were unequal, the left being less than the right. A slight ptosis of the left upper eyelid was present.

There was greatly diminished hearing in the left ear. The right ear was normal. Bone conduction was greater than air conduction in the left ear. The Weber test was referred to the left ear.

There was a complete left facial paralysis.

There was retention of urine.

On March 22, 1927, roentgen examination showed the presence of a bullet in the left side of the neck below the occiput. There was a fracture of the left temporal bone. There was also a bullet in the left side of the thorax, rather posteriorly, opposite the fourth rib. On April 29, 1927, the roentgen examination showed the presence of a bullet in the left posterior cervical region opposite the second and third cervical vertebrae, immediately above the needles which were anterior and posterior to the bullet.

Results of Laboratory Tests

Examination of Blood	Erythrocytes	Hemoglobin, per Cent	Leukocytes	Polymorphonuclears	Lymphocytes
March 21, 1927.....	4,200,000	80	14,650	80	20
March 28, 1927.....	.....	90	19,000	82	18
April 4, 1927.....	.....	75	16,000	80	20
April 10, 1927.....	.....	80	12,000	75	25
April 15, 1927.....	.....	70	12,000	80	20
April 28, 1927.....	5,000,000	80	12,000	78	22

The results of the laboratory tests are shown in the accompanying table. The reaction to the Kahn test was ++.

Course.—On May 2, 1927, the patient was able to move the left arm and leg, but could not sustain them. There was still retention of urine.

On May 3, 1927, there was slightly greater movement of the left leg and arm. There was an increase in the deep reflexes on the left side, with the exception of the achilles reflex which was lost. There was complete loss of pain and temperature sense on the right side from the second cervical dermatome downward. A pin scratch on the right side caused a disagreeable sensation. During an alcohol sponge bath, there was great discomfort on the right side, which was described as a "burning sensation"; the patient attempted to move her body away from the nurse as she sponged the right side.

On May 4, 1927, the spinal fluid showed xanthochromic fluid in three test tubes. The patient could elevate the left hand above the head and sustain it in this position. She could elevate the left leg, but it quickly fell back on the bed. The reflexes on the left side showed hyperactivity, and there was no pain sensation on the right side.

On the following day the patient voided urine for the first time.

The spinal fluid was clear and colorless on May 13, 1927, the manometric reading being 100 mm.

On May 16, 1927, the patient could move the left arm and leg, without any impairment of motion, but in testing resistance to passive movement, the strength

was less than in the right arm. She was out of bed and sitting in a chair. It was noted that there was loss of feeling on the right side of the urethra when urine was voided and also on the right side of the rectum when feces were passed.

On May 17, 1927, she was able to walk, but complained of weakness and dragging of the left leg.

The patient was discharged on May 25, 1927.

On June 2, 1927, the patient returned to the hospital for further neurologic examination. She was able to walk and run well. When standing on the left foot there was slight swaying, but none was present when the patient stood on the right foot. The deep reflexes were more active in the left than in the right extremities. The abdominal reflexes were absent on the left side and active on the right side. There was a bilateral plantar reflex. The muscle strength was slightly less in the left arm and leg. There was slight atrophy of the left arm and leg. There was a Hoffman sign on the left side. The cranial nerves were the same as at the former examination. Sensory examination showed the same loss to pain and temperature sense on the right side from the second cervical dermatome downward.

An examination with special attention to affect and feeling tone revealed many interesting hyperpathic sensory changes, limited to the right side of the body, from the second cervical dermatome downward, corresponding to the area of loss of pain and temperature sense. Stroking with cotton caused a "tickling feeling," while scratching with a pin was described as "feeling funny," an "uneasy feeling," "tickling" and an "electrical feeling." A pin point on the perineum caused a "pinch" or "pain" sensation, but less so than on the left side. Heat gave a feeling like an electric shock, and the patient stated that she dropped hot pots because the electric shock up the right arm was so intense. Extreme cold caused a disagreeable "burning and electric feeling." Grasping the right arm and calf of the right leg with extreme pressure caused a "tickling feeling." With the pin scratch and extreme pressure there was a radiation of the disagreeable feeling of about 8 or 9 inches (20 or 22 cm.) with a duration of from ten to fifteen seconds.

Electrical examination showed that on the side of the body with loss of pain and temperature senses, a strong faradic stimulation gave the sensation of "thrill and tickling" with a "disagreeable feeling," but there was no pain. With stronger electrical stimulation, this sensation became more disagreeable, and the patient squirmed and pulled away from the examiner. The "disagreeable tickling" was usually referred toward the end of the nerve. This was experienced in the upper and lower extremities, thorax and abdomen of the right side.

There was a normal gait and ability to run, and slight ataxia in the upper and lower extremities.

On Oct. 30, 1927, the deep reflexes on the left side were hyperactive, but only slightly greater than on the right, with the exception of both achilles reflexes which were absent. The left abdominal reflexes were absent, while those on the right side were active. There was a plantar reflex in both feet. There was a Hoffman sign in the left hand. The cranial nerves showed the same changes as on former examinations. Sensory examination revealed a change. In the second, third, and fourth cervical dermatomes, on the right side, there was partial return of pain and temperature sense. From the fourth cervical dermatome downward, there was still loss of pain and temperature sensibility. She was unaware of burns and cuts on the right hand and arm until the wounds were seen.

When the patient stood for any length of time, such as when washing and ironing, there was a disagreeable burning sensation in the entire right foot, and this burning feeling was referred with diminished intensity to the right knee. Frequently, the shoe on the right foot had been removed with little or no relief. Often there was an itching of the right half of the body, especially in the chest and abdomen, and when she scratched these regions for relief there was such a disagreeable tickling sensation that she quickly discontinued the scratching. On placing the right hand in cold water the hand felt warm after a short interval. When she placed the right hand in hot water, there was a burning sensation which was referred to the right shoulder. Faradic stimulation gave a disagreeable reaction, but apparently it was less disagreeable than had been experienced at the former examination. The cranial nerves were unchanged.

CASE 2.—*History.*—W. B., a man, aged 37, married, an American negro, a tailor, at 1:30 a. m. on April 3, 1927, was in a barber shop and had risen from a sitting to a standing position when he was suddenly stabbed in the back of the neck. He sank slowly to the floor, and was unable to rise. Friends assisted him to his feet, and he was able to put his right arm around the neck of one friend, but was unable to move the left arm. With assistance, he was able to stand with his weight on the right foot, but his left was useless. He was placed in a taxicab and a few minutes following the accident was admitted to Harlem Hospital with the following complaints: headache and dizziness, inability to move the left arm and leg, inability to turn the head toward the left, pain in the left side of the neck, left shoulder, arm and leg. The patient had been in excellent health prior to receiving the stab wound. He was a moderate drinker of tea and coffee, and at times drank alcohol to excess. His sexual habits were normal. Micturition was normal until the time of the accident since when there had been incontinence.

Neurologic Examination.—April 4, 1927. The patient was restless and lay on his right side. The head was supported by the right hand in a position of extreme retroflexion, with a slight tipping of the chin toward the right. The right leg was flexed at the knee, and the left arm and leg lay limply in an extended position. There was a stab wound in the posterior cervical region at the level of the second and third cervical vertebrae, diagonal in direction and slightly to the left of the midline. There was considerable swelling surrounding the wound and extending toward the left maxilla and left suprascapular region. The patient was unable to walk or stand.

The coordination tests were normal with the right arm and leg; it was impossible to test the left arm and leg because of the paralysis.

The deep reflexes on the left side were all hyperactive, and there was a transient ankle clonus, while on the right side, the deep reflexes were active. The superficial reflexes revealed an absence of the abdominals on the left side, while those on the right side were active. There was a Babinski and Chaddock reflex in the left foot, and a plantar reflex in the right foot.

Tests of the muscle strength revealed that the patient was unable to rise from a recumbent to a sitting position, and from a sitting to a standing position. The unopposed and opposed movements were performed normally in the right upper and lower extremities. There was no contraction of the muscles in the left upper and lower extremities. He was unable to flex his head, but could turn the head toward the left with assistance.

There was an increase in volume and contour of the left postcervical region, but it was difficult to determine how much of this was due to muscle change. There was hypotonus in the muscles of the left upper and lower extremities,

as tested by resistance to passive movement and extensibility at the joints. There was no irritability or myoidema. There was a slight Hoffman sign on the left side.

A general sensory examination revealed that touch acuity, localization and discrimination were normal on both sides of the body, with the exception of diminution in the left second, third and fourth cervical dermatomes. Pain sense was lost on the right side, from the second cervical dermatome downward. There was a diminution of pain sense on the left side, in the second, third and fourth dermatomes including the second cervical distribution on the cheek. There was a loss of hot and cold appreciation from the second cervical dermatome downward on the right side. On the left side there was diminution to hot and cold at the second, third and fourth cervical dermatomes.

Vibratory, pressure, muscle tendon, stereognosis and barognosis were normal throughout the entire body.

The cranial nerves were normal, with the exception that there was a slight ptosis of the left upper eye lid and moderate drooping of the mouth.

A roentgen examination of the cervical region failed to show any evidence of a lesion. The spinal fluid was uniformly bloody in three test tubes and registered 225 mm. of pressure. The Wassermann test with the spinal fluid was negative.

There was incontinence of urine.

Course.—On April 5, 1927, the patient still assumed the same attitude, lying on the right side of the body with the head held in a retroflexed position and supported on the right hand. He complained of pain in the posterior cervical region, left shoulder and arm. There was no return of muscle strength in the left upper and lower extremities. There was the same loss of pain and temperature sense on the right side of the body from the second cervical dermatome downward.

On the next day he could move the left leg, but could not sustain it. There was a palpable contraction of the muscles of the left arm, but no movement of the arm. The deep reflexes of the left upper and lower extremities were hyperactive and greater than those on the right side. There was no change in the sensory loss for pain and temperature. There was urgency in urination.

On the following day, he could lift the leg and maintain the position. He could lift the left arm slightly and sustain it for a few seconds. There was the same loss of pain and temperature sense.

The patient was discharged to his home at his own risk on April 8, 1927.

On May 11, 1927, he was readmitted to Harlem Hospital for examination. The patient stated that the strength had gradually returned in the left arm and leg and that he had been able to walk with the assistance of a cane since April 24, 1927. He still complained of sharp shooting pains in the left side of the neck, left shoulder and arm, but to a less degree than formerly.

There was a beginning claw hand on the left side. He walked with a circular swing of the left leg and scraped the toes of the left foot on the floor. There was no Romberg sign. He stood normally on the right foot, but there was a slight incoordination on standing on the left foot. The nonequilibratory test of the left upper and lower extremities showed a slight ataxia. There was a slight adiadokokinesis of the left hand. Skilled acts were normally performed. There were no abnormal involuntary movements. The deep reflexes of the left upper and lower extremities were all hyperactive. The abdominal reflexes were diminished on the left side, and there were Babinski and Chaddock reflexes in the left foot. The muscles of the left upper and lower extremities showed a degree of strength slightly less than those on the right. There was a slight atrophy of the muscles about the left shoulder girdle, left arm and leg. The Hoffman sign was present on the left side.

A sensory examination revealed a loss of pain and temperature sense on the right side of the body from the second cervical dermatome downward. There was a slight diminution to tactile, pain and temperature sensibilities in the second, third and fourth cervical dermatomes on the left side. There were no other sensory changes. An examination for feeling tone gave interesting observations. Stroking with cotton gave a "thrill or tickling" on the right trunk, arm, abdomen, outer thigh, inner calf, and both dorsal and plantar surfaces of the foot. The tickling sensation spread usually distally toward the end of the nerve. This was true on the abdomen toward the midline and thigh toward the foot, and was actually felt along the thigh to the big toe. On stroking the right side of the sacral saddle, the thrill or tickling was referred to this area and down the back of the thigh and leg to the foot and toe. Stroking the first and second lumbar dermatomes was referred to the knee; stroking the second and third lumbar dermatomes was referred to the inner side of the knee, downward to the foot and big toe.

On the right side of the body, pricking and scratching with a pin caused a strong feeling of "thrill" and a more "disagreeable tickling" sensation. The spread was the same, but more intense. Cold gave a disagreeable "thrill." In the ventral thoracic region the disagreeable sensation was referred toward the midline and downward to the right of the midline. Stimulation of the tenth thoracic was referred to the umbilicus; that of the second lumbar was referred from the posterior thigh to the calf of the leg. Heat gave a less disagreeable sensation than cold, but not a burning sensation, and there was much less spread in this sensation. Testing the pilomotor reaction by dropping ether on the posterior trunk and buttock regions showed slightly greater reaction on the left than on the right side.

On the right side of the body, faradic stimulation gave a "dull tickling" sensation without a sting. There was also a feeling of vibration. As the electrical stimulation was increased in strength, he described the tickling sensation as "more disagreeable" and without pain, that he could stand it; it did not hurt him, but was disagreeable and went "through" him more. With still greater strength in the electrical stimulation, he squirmed, trying to get away from it, and also said it did not hurt him, but was "terribly disagreeable." The spread of disagreeable feeling with faradic stimulation was the same for touch, pin scratch and temperature, but much more intense. Using faradic stimulation on the left side of the body the threshold at times seemed lower than on the right side. Also on the left side there was great pain and stinging, and the "hurt feeling" became intolerable. He complained of much burning, and said that he could not stand it.

The cranial nerves were normal, with the exception of a slight ptosis of the left upper eyelid and a slight drooping of the left corner of the mouth.

On Oct. 20, 1927, the patient still complained of pain in the left posterolateral region of the neck and left shoulder with radiation to the left hand. The pain was increased on movement of the neck and left shoulder. There was a slight stiffness of the left hamstrings on walking and running. There was some atrophy about the left shoulder girdle, left arm and hand. There was a claw-hand attitude of the left hand. No Romberg sign was present. There was a slight incoordination in the left upper and lower extremities, in the finger-to-nose and heel-to-knee tests, respectively. The deep reflexes of the left upper and lower extremities were hyperactive and slightly greater than those of the right. The left abdominal reflexes were diminished, while the right abdominal reflexes were normally active. There was a Babinski reflex in the left and a plantar reflex in the right foot. There was a Hoffman sign in the left hand.

A sensory examination showed a beginning return of pain and temperature sensibilities on the right side of the body. In the second and third cervical dermatomes there seemed to be a return to nearly normal pain and temperature sense. The fourth cervical dermatome had only a slight diminution of these senses. From the fourth cervical to the first thoracic dermatome, there was recognition of pain and temperature stimuli, but they were somewhat diminished. From the first thoracic dermatome downward, pain and temperature sensations were still lost. On the left side there was a diminution to tactile, pain and temperature senses in the second, third and fourth cervical dermatomes.

The examination for feeling tone on the right side with cotton, pin scratch, cold and heat revealed the same disagreeable tickle with referred sensation, but to a less degree than on the former examination. The faradic stimulation still gave a disagreeable, dull, tickling sensation without any sting. There was radiation, and the patient still squirmed away during the examination, but less violently than before.

The cranial nerves were normal, except for the slight ptosis of the left upper eyelid and a slight drooping of the left corner of the mouth. The urgency in urination disappeared in September, 1927. There was slight impotence.

SUMMARY AND CONCLUSIONS

The two patients were in good health until they received wounds in the left cervical region involving the spinal cord at about the second and third cervical dermatomes. In each case there was sudden flaccid hemiplegia on the side of the lesion and loss of pain and temperature sensibility on the opposite side. The flaccid paralyses soon became spastic, and in the course of a few weeks, there was almost complete recovery of muscle strength in the paralyzed limbs. Reflex signs and abnormal associated movements still remained as evidence of the upper motor neuron paralysis.

On the side opposite to the lesion, in each case, there was a loss of pain and temperature sense from the second cervical dermatome downward. There were no other sensory changes, except that in one case the second, third and fourth cervical dermatomes on the side of the lesion revealed an impairment of tactile, pain and temperature sensibilities with, later, some atrophy of the muscles about the left shoulder girdle. Hyperpathic sensibility revealed exaggerated feeling tone in both cases on the right side, where there was a loss of pain and temperature sensation. This was usually referred toward the end of the nerves.

The sensory changes have shown a beginning recession: In case 1 there was a beginning return of pain and temperature to the fourth cervical dermatome. In case 2 there was a beginning return of pain and temperature sensation to the first thoracic dermatome. In one case there was a retention of urine for several days; in the other, an incontinence of urine for a few days. Both patients now have normal voluntary urinary control. At the present time both patients are performing their usual duties.

It is thought that in both cases there was a partial hemisection of the left side of the cervical spinal cord. The site of the lesions is known with accuracy, and their nature limits the lesions to definite areas. The limitations are shown by the results of examinations made several months after the injuries were received. With the clinical signs of an upper motor neuron paralysis on the side of the lesion and loss of pain and temperature sensation from the second cervical dermatome downward on the side opposite the lesion, it is thought that the wounds are discretely limited to the pyramidal and lateral spinothalamic tracts on the left side of the cord. At any level in the cord the secondary tracts for pain and temperature from the lower spinal dermatomes have crossed from the opposite side. Pyramidal pathways which crossed above continue downward on the same side of the cord.

It is thought that the functional loss in these cases is not due entirely to structural damage.[8] It is certain that neither the cells nor the fibers of the spinal cord regenerate,[9] and hence improvement cannot be ascribed to such regeneration. However, edema and other circulatory disturbances exist in the neighborhood of a traumatic lesion and may be the basis for many of the early symptoms which show considerable improvement later.

Shock, defined by Sherrington [10] as the whole of that depression and suppression of nervous function which ensues forthwith on a mechanical injury of some part of the nervous system and is of temporary nature, may explain the temporary flaccid type of left hemiplegia in each of these cases.

The pyramidal tract is situated more mesially than the lateral spinothalamic pathway, and therefore was probably less severely damaged than the latter, in a lesion which obviously involved the edge of the cord; this may, in part, account for the rather rapid recovery of function of the pyramidal tract.

Head [11] stated that when there is an exaggerated affect or feeling tone on the side of loss of pain and temperature sensation; it is essential that tactile sense be intact. In these cases, tactile sense was preserved on the side of loss of pain and temperature, and the aggravated affect or feeling tone was extreme; here, tactile sensibility must subserve the function of transmitting the sensations of discomfort as it did in Head's cases.

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8. Riddoch, George: Brain **40**:264, 1917-1918.

9. Holmes, Gordon: Spinal Injuries of Warfare, The Goulstonian Lecture, 1915.

10. Sherrington, C. S.: The Integrative Action of the Nervous System, London, Constable and Company, 1906, p, 240.

11. Head, Henry: Studies in Neurology, New York, 1920, vol. 2, p. 405.

INTRASPINAL IODOLOGRAPHY

SUBARACHNOID INJECTION OF IODIZED OIL AS AN AID IN THE DETECTION AND LOCALIZATION OF LESIONS COMPRESSING THE SPINAL CORD *

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The introduction of iodized oil 40 per cent into the intraspinal subarachnoid space by means of cisternal puncture, for roentgenologic visualization of the patent or locally obstructed subarachnoid space in patients revealing signs and symptoms of compression of the spinal cord, was introduced by Sicard [1] eight years ago. The method has won a prominent place in neurologic clinics abroad, where it is now almost a routine diagnostic procedure employed whenever an intraspinal neoplasm is suspected. Neurologists and neurosurgeons [2] in this country, however, with few exceptions, have not adopted the method, maintaining that it is an unnecessary and undesirable procedure, which offers no advantage over older neurologic methods and tests. It is further argued by them that: (1) as another mechanical diagnostic aid, it menaces the development of an acute clinical sense; (2) the iodized oil is an irritant and as such may lead to undesirable meningeal complications; (3) because of its slow absorption it may become encapsulated, so that pseudotumor formations will arise and provoke new symptoms, and (4) the cisternal method, which is usually employed in the injection of the iodized oil, is fraught with danger to life and is an added hazard not justified by the results obtained from the diagnostic test.

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1. Sicard, J. A., and Forestier, J.: Méthode radiographique d'exploration de la cavité épidurale par le lipiodol, Rev. neurol. **37**:1265, 1921; Méthode générale d'exploration radiologique par l'huile iodée (lipiodol), Bull. et mém. Soc. méd. d. hôp. de Paris **46**:465, 1922.

2. Since the preliminary presentation of this paper, Frazier and Glaser (Iodized Rape-Seed Oil [Campiodol] for Cerebrospinal Visualization, J. A. M. A. **91**:1609 [Nov. 24] 1928) have published an excellent article describing their experiences with the use of rape-seed oil in iodolography.

All these objections are raised in the face of the claims made by Sicard,[3] which may be summed up as follows: (1) injections of iodized oil are remarkably free from painful reactions and untoward sequelae; (2) iodized oil is well tolerated by tissues of the central nervous system; (3) iodized oil is easily outlined by the x-rays and hence is of great assistance in determining and localizing subarachnoid block caused by a compressing lesion.

The accumulating literature on the subject, particularly from European sources,[4] bears out in full the claims of Sicard and his co-workers, but aside from an occasional case report or brief statement, little has appeared in the literature in this country to support these claims or to alter or confirm the generally hostile attitude to iodolography.

MATERIAL

Our study is based on an analysis of sixty-four cases. In the majority of these cases the iodolography served as a deciding factor in reaching a final diagnosis, and in many cases it helped to define and accurately localize the lesion. Many of the cases included herein presented somewhat vague sensory manifestations, an indefinite sensory level or other atypical features which taxed the older diagnostic methods, and only by the aid of iodized oil was it possible to come to a definite conclusion, particularly when it was imperative either to establish or to exclude the presence of an operable lesion of the spinal cord. The material consists of a fairly wide variety of diseases of the spinal cord, as is obvious from the following list of types of lesions of the cord: (1) extramedullary intradural tumors of the cord, twelve cases; (2) extradural primary intraspinal tumors, three cases; (3) extradural secondary malignant intraspinal tumors, three cases; (4) intramedullary tumors of the cord (including central gliosis and syringomyelia), ten cases; (5) pachymeningitis with symptoms of compression of the cord, one case; (6) arachnoiditis with symptoms of compression, three cases; (7) lumbosacral radiculitis with signs indicating the possibility of tumor of the cord, nine cases; (8) multiple sclerosis with sensory changes suggestive of a level lesion, nine cases; (9) amyotrophic lateral sclerosis with some atypical manifestation, three cases; (10) diffuse degenerative lesion of the spinal cord, two cases; (11) transverse myelitis of atypical form, four cases; (12) dilated veins of the spinal cord simulating tumor of the cord, one case; (13) abnormality of the spinal canal (spina bifida

3. Sicard; Haguenau and Laplane: Transition lipiodolé rachidien, technique sous-arachnoidienne, resultats diagnostiques, Rev. neurol. **1**:1 (Jan.) 1924.

4. Peiper, H.: Die Myelographie im Dienste der Diagnostik von Erkrankungen des Rueckenmarkes, Ergebn. d. med. Strahlenforsch. **2**:109, 1926. Sicard, J. A., and Forestier, J.: Diagnostique et therapeutique par le lipiodol, Paris, Masson et Cie, 1929.

occulta), one case; (14) psychoneurosis with symptoms simulating tumor of the spinal cord, one case; (15) disease of the peripheral vessels of the extremities with symptoms leading to the diagnosis of tumor of the cord, one case.

The total is not particularly large but consists of carefully selected cases. In choosing material for the employment of this method, we were not guided by an attempt to assemble an impressive number, but by the clinical merits of each case. Whenever the clinical symptoms were such as to arouse a strong suspicion of the existence of an intraspinal tumor and whenever under these circumstances other diagnostic methods failed to exclude the existence of locally compressing intraspinal lesions, the iodized oil test was regarded as indicated. Thus, though the number of cases showing a negative result of the iodolographic examination is large, it should nevertheless be understood that in every instance in which no tumor of the spinal cord was found the clinical picture was such as to give sufficient reason for the suspicion of the existence of such a lesion. This will be verified by the study of the individual clinical histories.

METHOD

In almost every case, before iodolography was done, a manometric estimation was performed. In many instances the need of iodolography was obviated by negative manometric readings, especially when the clinical examination only slightly suggested intraspinal compression. When, however, a partial block was revealed by the manometric readings, iodolography was considered indicated. An interval of at least five days was allowed before the oil was injected after spinal puncture, so as to avoid any possible error which might occur as the result of the removal of cerebrospinal fluid.

The preparation of the patient for the iodolographic test consists of shaving the back of the head as far up as the external occipital protuberance. One half hour before the cisternal puncture is carried out, the patient is given a hypodermic injection of morphine, ¼ grain (16 mg.), and scopolamine, 1/150 grain (0.4 mg.). The cisternal puncture is done with the patient lying on his side, the head resting on a pillow, which is placed in the hollow of the neck so as to keep the head exactly in line with the axis of the body. To indicate even the slightest change in the alinement of the patient's head, which might interfere with successful puncture of the cistern, one of us (Globus) devised the following method: The back of the patient's neck is scratched by a sharp pin so as to map out a series of squares which remain visible after the area is covered with iodine (fig. 1). A disturbance in the regularity of these spaces enables one to note whether the patient has moved his head, so that it may be straightened before the needle is inserted.

After the oil (2 cc. of iodized oil) is injected and before the needle is withdrawn, the stylet is reinserted so as to clear the lumen of the needle of the remaining small amount of iodized oil. It is again withdrawn so as to allow a few drops of cerebrospinal fluid to escape. This additional precaution is taken to ascertain whether the needle was in place during the injection and whether the

oil entered the subarachnoid space. The needle is then withdrawn. The patient is made to sit up and is ready for roentgenography. The first series of roentgenograms are taken within half an hour after the injection. Should the iodized oil be found to have descended to its normal level (fig. 2), no reexamination by the x-rays will be necessary; if some of the oil should become arrested at a higher level (fig. 3) another series of pictures is taken on the following day in order to see whether the iodized oil block is permanent. Occasionally, a fluoroscopic examination is made immediately after the injection of oil to observe the speed of its descent.

OBSERVATIONS

GROUP I: INTRADURAL AND EXTRAMEDULLARY NEOPLASMS

This group consists of twelve cases verified by laminectomy. Iodolography not only helped to substantiate the clinical observations which pointed to the existence of an intraspinal lesion compressing the spinal cord, but it indicated accurately the seat of the lesion in eleven cases, thus guiding the surgeon directly to the lesion. He thus avoided the unnecessary removal of vertebral laminae. It shortened the time of the operation and eliminated the frequent unsatisfactory probing for a tumor when its probable site is not apparent in the field exposed.

ILLUSTRATIVE CASES

CASE 1.—*History.*—G. S., a woman, aged 41, was first admitted to the hospital on July 21, 1925, complaining of pain in both knees and of weakness in the right leg of three months' duration. The gait was unsteady, and she dragged the right leg. There were diminution in the temperature sense in the left lower extremity on its mesial aspect, an increased left knee jerk and an inconstant right Babinski sign. A lumbar puncture revealed clear, colorless fluid under normal pressure, containing 4 cells. The Wassermann test was negative. A neoplasm of the spinal cord was suspected, but because of the meager observations surgical intervention was delayed.

The patient returned eleven months later when she presented the following signs: spastic paralysis of both lower extremities, the right more than the left; a bilateral Babinski sign; bilateral ankle clonus, and sensory changes below the second dorsal level (fig. 4).

Manometric Estimation.—Examination revealed partial subarachnoid block with an initial pressure of 280 mm.; on coughing, of 310 mm., and on jugular compression, of 360 mm. The fluid was somewhat cloudy, but contained only 2 cells per cubic millimeter. At this time the diagnosis of an extramedullary neoplasm at the second dorsal level was regarded as most probable.

Iodolography.—Iodized oil, injected by cisternal puncture, was arrested at the junction of the sixth and seventh cervical vertebrae (fig. 5, *A* and *B*). The iodized oil was found on the following day practically in the same amount and at the same location; none of it had escaped downward. This substantiated the diagnosis of an extramedullary neoplasm, but the level was now fixed at the fifth cervical.

Laminectomy and Course.—An extramedullary neurofibroma was found at the level indicated by the iodized oil and was removed (fig. 6). The patient made an uneventful recovery. At the time of discharge from the hospital, power had returned to the lower extremities and the sensory disturbances had disappeared.

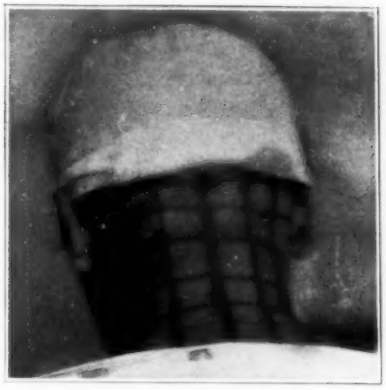

Fig. 1.—Markings on the back of the neck. The head is held in a straight line.

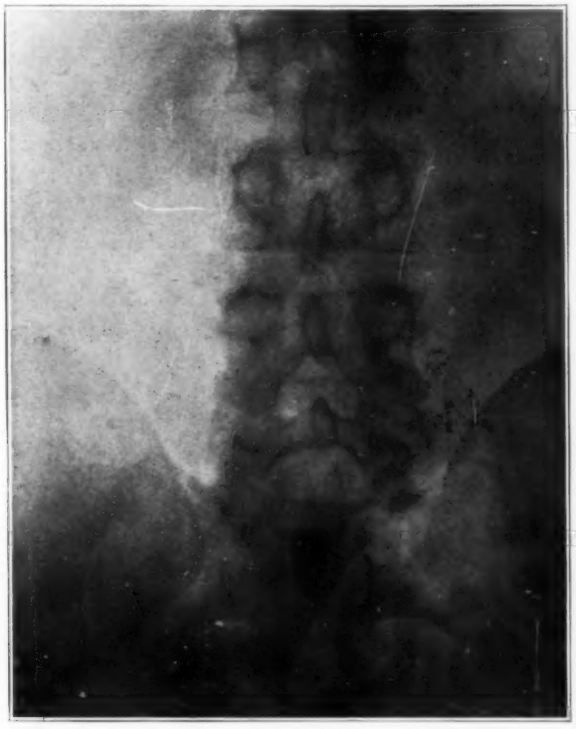

Fig. 2.—Normal iodologram.

Comment.—A comparison of the levels obtained from the clinical signs and from the iodolography showed that there was no wide discrepancy in the location of the lesion. If surgical approach had been made at the first dorsal vertebra, the surgeon would probably have been inclined to go one or two vertebrae higher to reach the tumor. However, the iodologram indicated the site of the tumor accurately, and nothing was left to speculation.

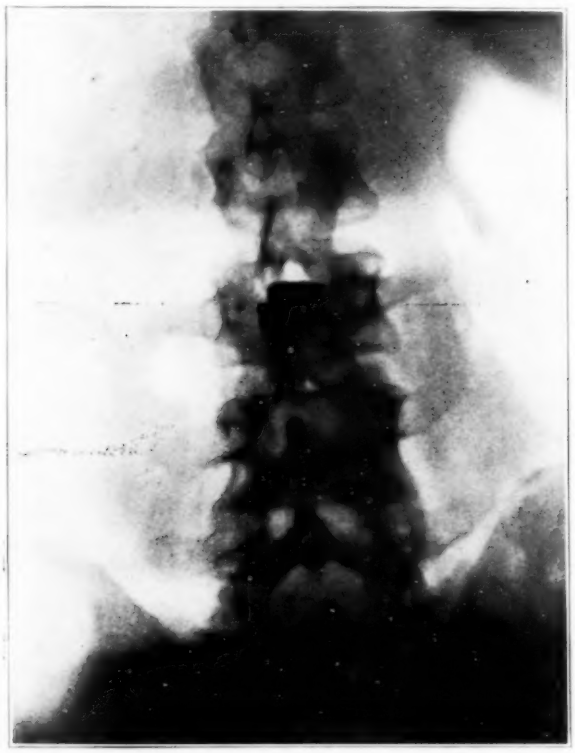

Fig. 3.—Iodologram.

Case 2.—*History.*—H. L., a man, aged 25, had always been well, except for an attack of influenza in 1918. In November, 1926, in the wake of an attack of grip, he suddenly developed pain in the sacral region. At this time he began to experience numbness in the right lower extremity. Following another "cold," there developed pain in the same leg and across the back. The condition remained stationary until two months before admission to the hospital when he began to lose power in both legs. Poliomyelitic serum was administered by a physician without beneficial results. Urinary disturbance and obstinate constipation soon developed.

Examination.—There were: flaccid paralysis in both lower extremities; absent knee and ankle jerks; an equivocal plantar reflex on the right side; atrophy of

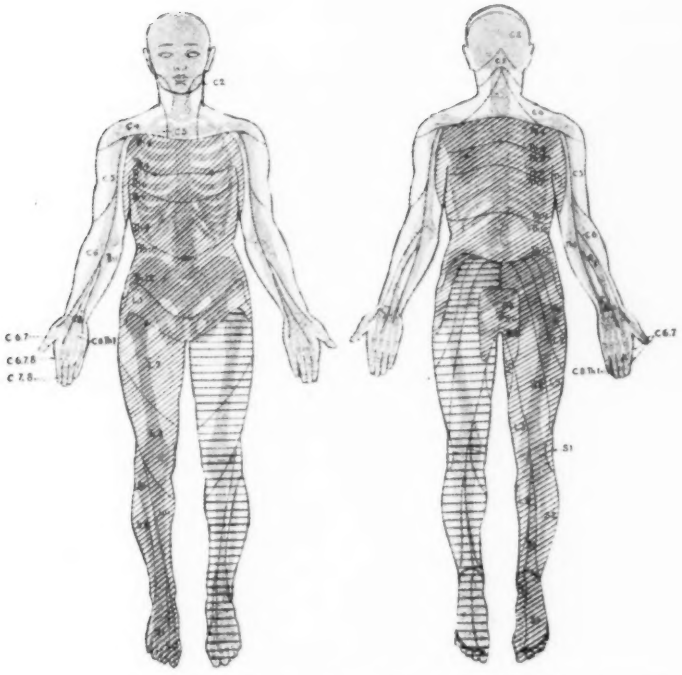

Fig. 4 (case 1).—Sensory chart. In this and the following sensory charts, the portion shaded with horizontal lines indicates the area in which sensation is lost; that shaded with widely spaced diagonal lines indicates slight diminution of sensation; with moderately spaced diagonal lines, moderate diminution; with closely spaced diagonal lines, marked diminution; with widely spaced vertical lines, slight increase; with moderately spaced vertical lines, moderate increase, and with closely spaced vertical lines, marked increase.

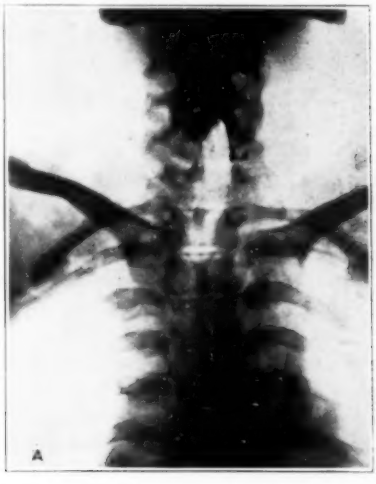

Fig. 5.—Iodologram from case 1.

the muscles of the legs; a belt of hyperalgesia in the twelfth dorsal dermatome; diminution of all forms of sensation below that level; loss of all forms of sensation below the knees (fig. 7).

The diagnosis was uncertain. Some members of the staff inclined to a diagnosis of an inflammatory lesion, while others favored that of an extramedullary neoplasm.

Manometric Estimation.—Examination revealed a partial subarachnoid block. The initial pressure was 200 mm.; on coughing, 220 mm.; on straining, 320 mm., and on jugular compression, 200 mm. The rise and fall were delayed. The fluid was xanthochromic, and contained 4 cells and an increased amount of globulin. Following this procedure, a diagnosis of tumor was favored.

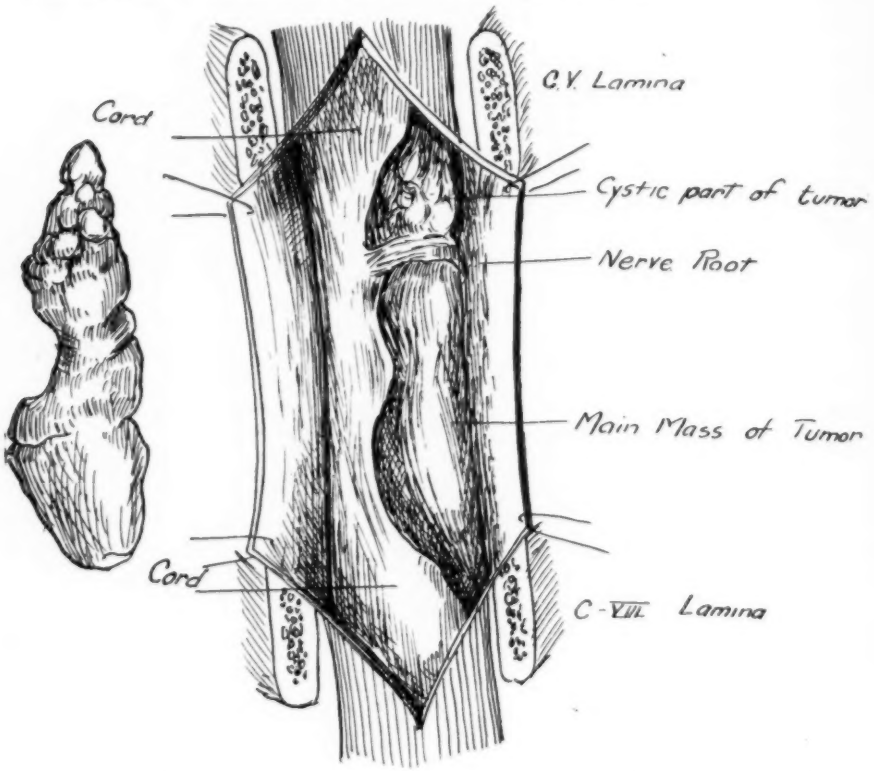

Fig. 6.—Drawing of tumor in situ in case 1. Actual size of tumor at right, 4.5 by 1.5 cm.

Iodolography.—Iodized oil was injected by cisternal puncture; the oil was partially arrested at the eleventh dosal level (fig. 8). It assumed the outline of two narrow streams at a short distance from each other. This picture has been described by others as suggesting an intramedullary lesion. In spite of this, an exploratory laminectomy was thought to be indicated. The patient reacted badly to the injection of iodized oil. He showed increased pallor, prostration, cold sweating, dilated pupils and a rapid pulse. He also complained of pain in the left lower quadrant of the chest. These manifestations of irritation, however, were transient.

Laminectomy and Course.—An extramedullary glioma at the eleventh and twelfth dorsal levels was removed. An uneventful convalescence was followed by marked improvement.

Comment.—The iodolographic observations were in the nature of a partial block, and corresponded to the manometric readings. The added information obtained from the injection of iodized oil, however, was the level at which the block had occurred, which as noted in figure 8 was at the eleventh dorsal level. The two narrow columns of iodized oil are usually taken to suggest an intramedullary neoplasm but, as revealed by laminectomy in this instance, apparently occur also with an extra-

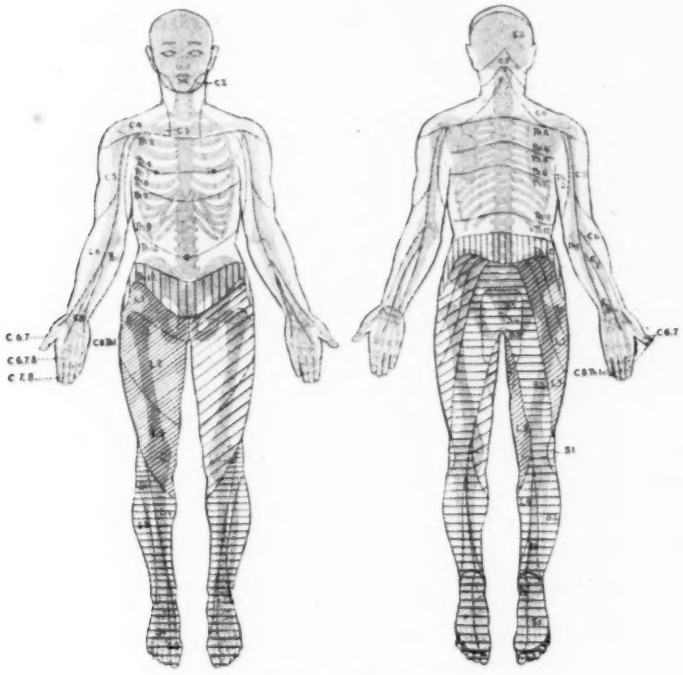

Fig. 7 (case 2).—Sensory chart.

medullary lesion. It is possible that the gliogenous character of the tumor is responsible for the atypical iodologram. It seems that one must be guarded in interpreting the shadow made by the iodized oil; one should not assign too much significance to variation in outline but should be satisfied to identify the existence of a block and its level and use other clinical data to establish the nature of the compressing agent.

Case 3.—*History.*—A. A., a woman, aged 53, for a year preceding admission to the hospital had noted stiffness, weakness and a burning pain in both lower extremities, more marked on the left side, and a dull ache in the lower part of the spine. During the last four months she had lost all forms of sensation in the

left lower extremity, and was subject to occasional sticking and creeping sensations in both lower extremities. There were no urinary disturbances except occasional urgency.

Examination.—Examination showed: a somewhat spastic gait; definite weakness of both lower extremities, the left more than the right; knee jerks and ankle jerks, active and equal; inconstant bilateral Babinski sign; absent left lower

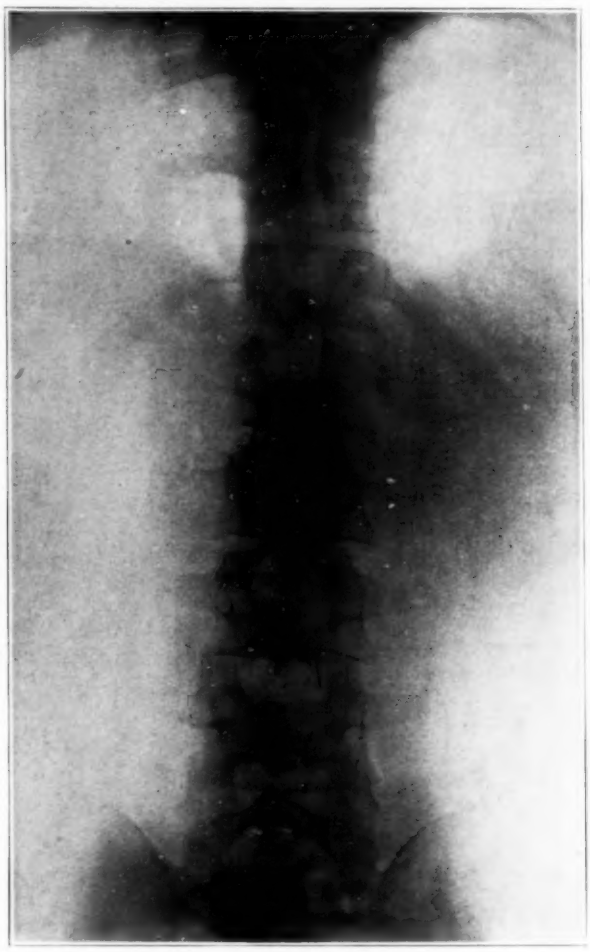

Fig. 8 (case 2).—Iodologram.

abdominal reflex; marked percussion tenderness over the middorsal spine; pain and temperature sense slightly impaired below the sixth dorsal level and markedly impaired below the tenth dorsal level on the right side, and completely lost on the left side below the eleventh dorsal level. Vibratory sense was diminished in the lower extremities; postural sense was grossly intact.

Manometric Examination.—Studies revealed a partial subarachnoid block. The initial pressure was 100 mm.; on straining, 200 mm. (the pressure fell to 180 in

five seconds), and on jugular compression, 480 mm. (it fell to 160 in forty seconds). The fluid was clear, and contained 2 cells; the Wassermann test was negative. Intramedullary disease was considered as the most probable diagnosis. Despite the existence of a partial subarachnoid block, there was a divergence of opinion as to whether the patient had an intramedullary or an extramedullary tumor. In order to arrive at a definite diagnosis, iodolography was performed.

Iodolography.—Iodized oil was injected by cisternal puncture. It was arrested at the ninth dorsal vertebra (fig. 9). The oil at this level assumed a paint-brush-like appearance. More than half of the oil descended into the dural culdesac. Examination on the following day showed persistence of the obstruction. Following the injection of iodized oil the patient complained of marked exacerbation of pain in the back, encircling the abdomen.

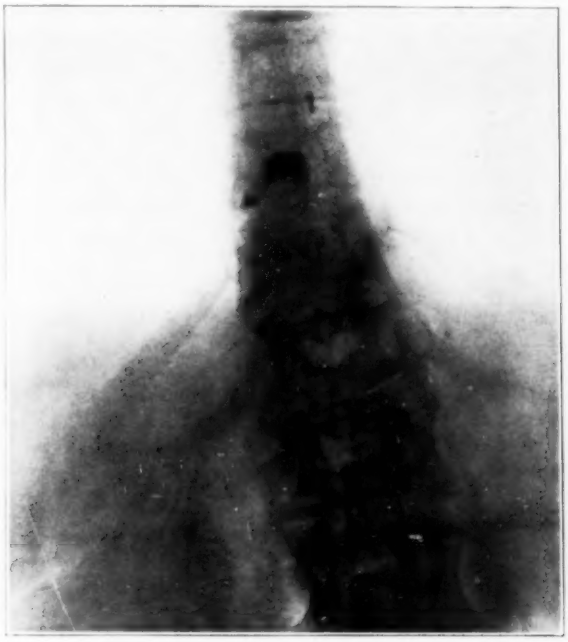

Fig. 9 (case 3).—Iodolgram (tracing).

In view of the discrepancy between the iodized oil level and the sensory level, the question was raised as to the possible existence of multiple lesions. A roentgenogram of the spine excluded the possibility of malignant disease.

Laminectomy.—A benign meningioma was found at the level indicated by the iodized oil and was removed. Recovery was rapid and highly satisfactory.

Comment.—The discrepancy between the level indicated by the sensory examination and that shown by the iodized oil block, and the uncertainty regarding the nature of the lesion proved the usefulness of the iodolography; this needs no further comment.

CASE 4.—*History.*—S. L., a man, aged 36, had a small furuncle on the inside of the right thigh fifteen months prior to admission to the hospital; it opened spon-

taneously. Shortly after, the patient noticed numbness on the other side of the right thigh. The numbness soon spread down to the foot. Somewhat later, he noticed that he could not recognize cold, while the sense of heat was unimpaired. Seven months later, he began to drag the left leg. A lumbar puncture precipitated an attack of drawing pain on the outside of the right thigh, and weakness developed in both legs, more in the right. Pain appeared in the lower part of the spine, and he became markedly constipated.

Examination.—Moderately spastic gait; paresis of both legs; hyperactive knee jerks, the left more than the right; hyperactive ankle jerks, the right more than the left; bilateral Babinski sign; absent abdominal reflexes; a sensory level at the tenth dorsal level, below which there was analgesia and athermesthesia except from the first to the fifth sacral segments on the left side where the patient perceived pin pricks and could recognize temperature to a slight degree; definite disturbance of the posterior column; a sweating level at the tenth dorsal level; difficulty in voiding and loss of control of the rectal sphincter were found. An intramedullary lesion, probably a tumor, was considered as the most probable lesion. A manometric estimation of the cerebrospinal fluid was not made.

Iodolography.[5]—Iodized oil, injected by cisternal puncture, was arrested at the sixth dorsal vertebra.

Laminectomy.—A subdural extramedullary tumor of the spinal cord at the level of the seventh dorsal vertebra, resting on the posterolateral surface of the cord, was removed. An uneventful convalescence and rapid recovery followed.

Comment.—The discrepancy between the sensory examination and the iodologram, and the results of the operation emphasize the value of this method.

Case 5.—*History.*—G. W., a girl, aged 15 years, had scarlet fever at the age of 10, and influenza at the age of 11. Five years before admission to the hospital, she began to experience pain in the coccygeal region. It radiated to the thighs and knees. There was a short remission of two months when she was free from the pain following the removal of the appendix and an ovarian cyst. The pain returned and became more constant and more intense; recently it became so severe as to keep her awake at night.

Examination.—There were: diminished right knee jerk and absent right ankle jerk; bilateral Lasègue sign; relaxation of the sphincter recti; diminution of pain, touch and temperature sense in the distribution of the fourth and fifth sacral roots. A neoplasm of the cauda equina or a metastatic process arising from the ovarian cyst were considered.

Manometric Estimation.—Examination revealed no apparent block. The readings were: initial pressure, 250 mm.; on coughing, 240 mm.; on straining, 520 mm.; on jugular compression, 480 mm. The fluid was xanthochromic and somewhat cloudy.

Iodolography.—Iodized oil was injected by cisternal puncture. The oil was arrested at the upper border of the fifth lumbar vertebra (fig. 10). Examinations on two consecutive days showed that almost the entire amount of iodized oil remained at this level.

Laminectomy.—A glioma, which invaded numerous roots of the cauda equina (fig. 11), was only partly removed, as thorough enucleation was considered

5. The iodogram in this case was lost and hence is not available for illustration.

dangerous. The tumor was found one or two segments below the level indicated by the iodized oil.

Comment.—This is the only instance in which the injection of iodized oil localized the lesion several segments above the level at which it was found at the operation. This may be explained by the possible existence of meningeal adhesions for a space of two segments above the level of the tumor. This case also indicates the value of iodolography in suspected lesions in the region of the lower part of the cauda equina, in which manometric estimation of the spinal fluid pressure will be of no service because the obstruction is below the usual site of lumbar punc-

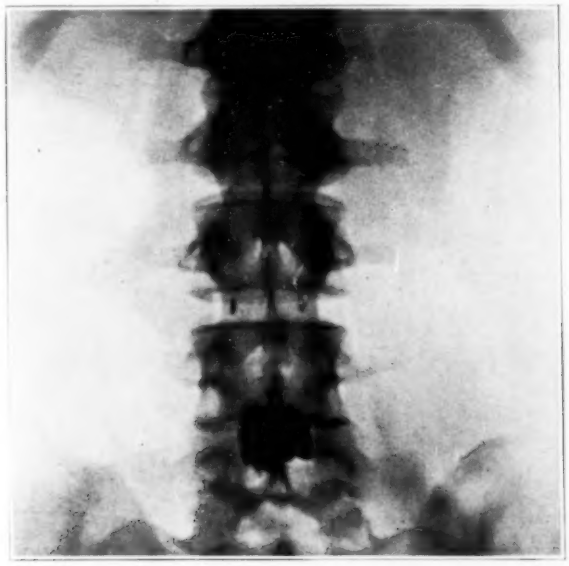

Fig. 10 (case 5).—Iodologram.

ture. In this case, the diagnosis of tumor was supported by the character of the cerebrospinal fluid, despite the absence of any indications of a block.

CASE 6.—*History.*—E. S., a woman, aged 57, whose father died at the age of 45 with symptoms suggestive of paresis, while a sister had so-called "shaking palsy," had had several spontaneous miscarriages. Two children are living and well. Three years before admission to the hospital, she began to drag the left foot. Soon after, she began to notice numbness in the left arm and weakness in the left hand. Somewhat later, she experienced occasional cramplike pains in the calf of the left leg and had occasional urinary urgency and incontinence. The condition remained unchanged for a period of thirteen months, at the end of which she was unable to walk and was completely incontinent of urine and feces. During the past two years she would experience girdle phenomena about the abdomen. Positive Wassermann tests of the blood and spinal fluid led to a diagnosis of cerebrospinal syphilitis and to active antisyphilitic treatment (fifty

injections of arsenic and fifteen of bismuth were given). This was without apparent benefit to the patient.

Examination.—The right pupil was irregular and larger than the left; there was weakness of the muscles of the trunk (the patient was unable to sit up), with partial atrophy of both hands with clawhand deformity. The deep reflexes in

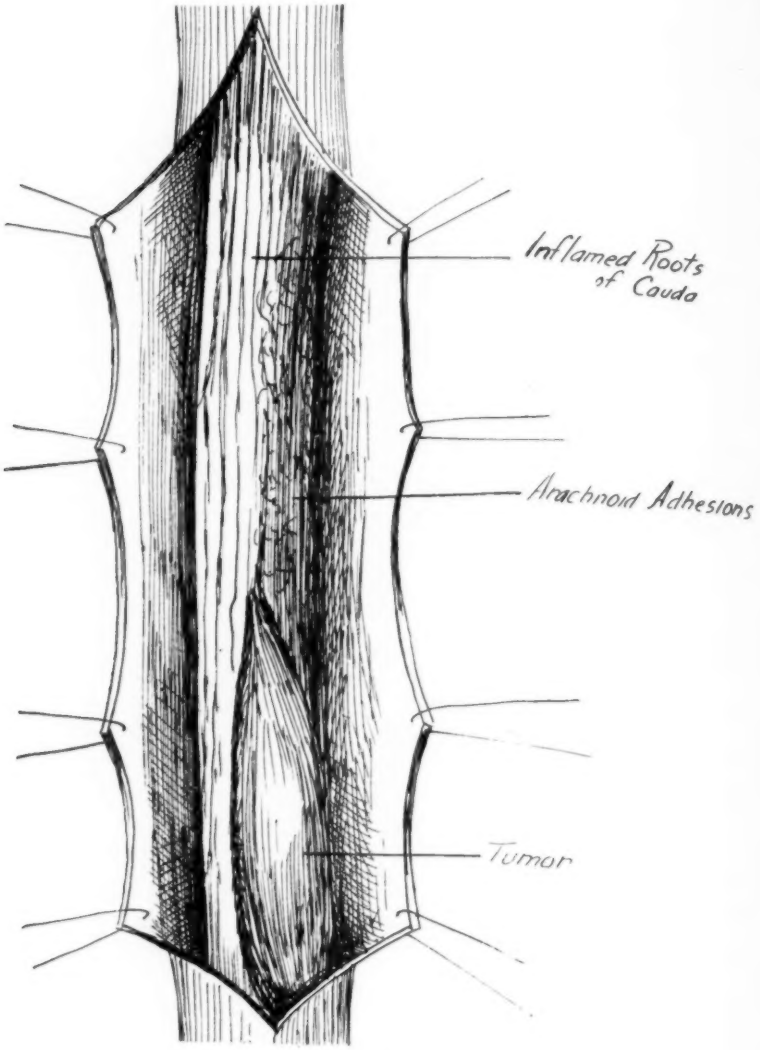

Fig. 11 (case 5).—Tumor in situ.

the upper extremities were hyperactive, more on the right than on the left. There were complete loss of power in both legs, absent abdominal reflexes and hyperactive reflexes in the legs, more on the left than on the right. Hyperalgesia was present in the lower cervical segments, below which sensation was diminished, markedly so in the sacral segments (all forms of sensation were affected as shown

in figure 12). Tenderness on percussion was present over the lower cervical vertebrae.

Manometric Estimation.—Examination revealed a total subarachnoid block, with the following readings: initial pressure, 40 mm.; on coughing, 40 mm.; on jugular compression, 40 mm. Eight cubic centimeters of cloudy, blood-tinged cerebrospinal fluid was obtained with difficulty. The Wassermann, colloidal gold and globulin tests of the fluid were negative. A diagnosis was made of compression of the lower cervical segments, probably by a neoplasm, the possibility of pachymeningitis syphilitica cervicalis being ruled out because of the long continued and intensive antisyphilitic treatment.

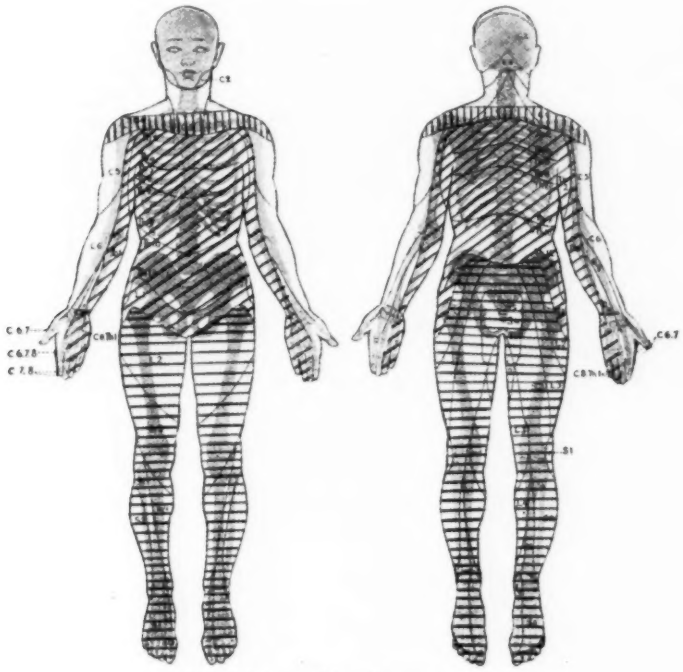

Fig. 12 (case 6).—Sensory chart.

Iodolography.—Iodized oil injected through a cisternal puncture was arrested at the lower part of the fourth cervical level (fig. 13). When a reexamination was made on the following day, it was found in the same location.

Laminectomy.—An intradural, extramedullary meningioma, lying at the level of the fourth cervical vertebra, was removed (fig. 14).

Postoperative Course.—The patient went through a slow but uneventful convalescence. She regained power and sensation in both lower extremities, to a greater extent on the right side. Motor power returned in the hands to a considerable degree. She regained control of the bladder function, but still had occasional difficulty in starting the flow. Recent reports show that the patient has almost completely recovered.

Comment.—In spite of the positive results of the serologic examination previously obtained, a syphilitic inflammatory condition of the cord

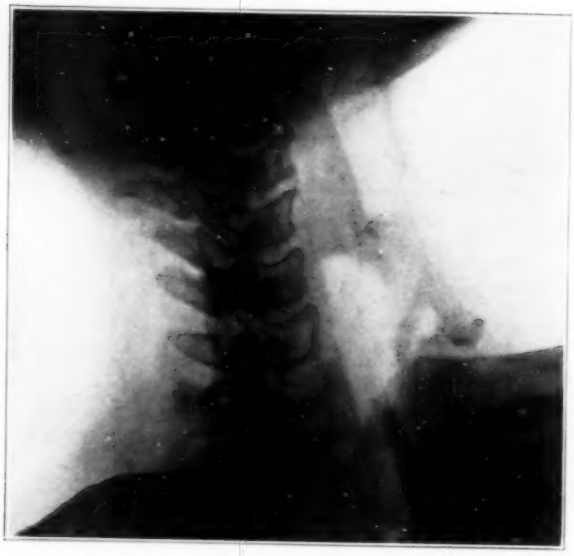

Fig. 13 (case 6).—Iodologram (tracing).

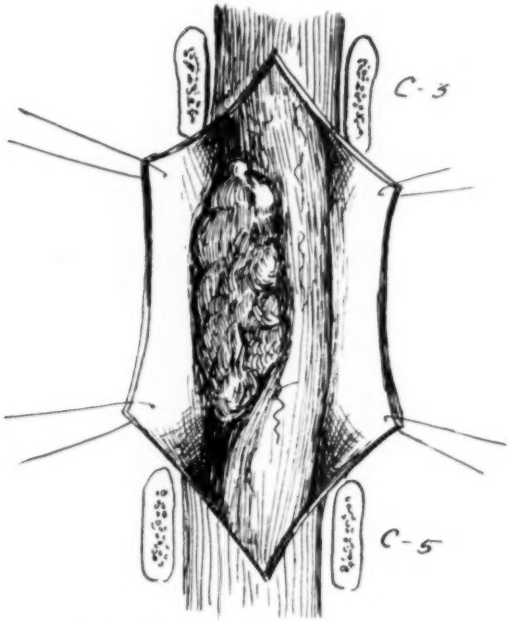

Fig. 14 (case 6).—Tumor in situ.

or its meninges was excluded, and a diagnosis of an extramedullary neoplasm was made. The iodolographic examination was confirmatory of the diagnosis and localization, and served as an additional guide to the surgeon.

CASE 7.—*History.*—B. H., a woman, aged 44, had had two miscarriages and had given birth to two living children. Two months prior to admission to the hospital, she suddenly developed a rash on both forearms; it itched slightly; as it began to fade, stiffness of the left hand developed, especially in the finger tips. The stiffness gradually became more marked, and the fingers grew increasingly

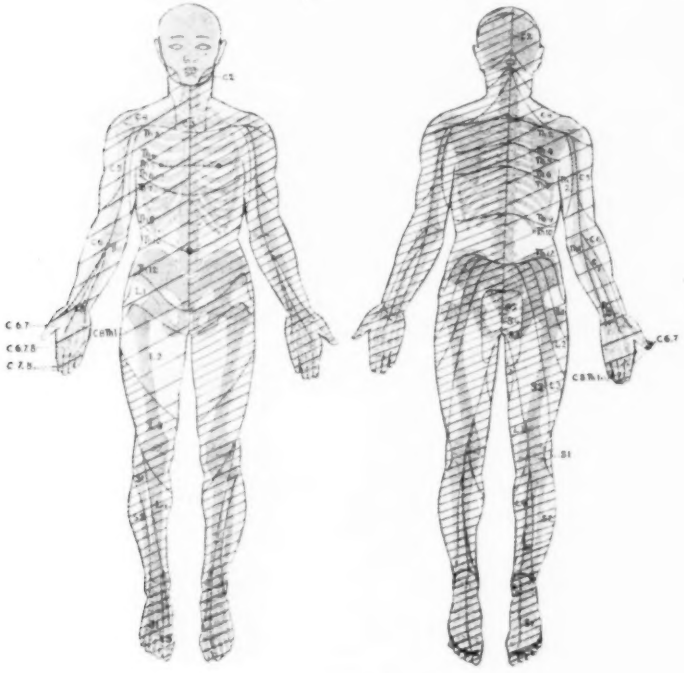

Fig. 15 (case 7).—Sensory chart.

numb. Two and one half months later, the right hand became similarly involved. With this there developed a sensation of extreme cold in the feet, so that she had to keep the extremities wrapped in blankets. The gait became unsteady and the hands tremulous. Recently, frequency and urgency of urination developed.

Examination.—Examination showed: weakness of the shoulder girdle muscles and moderate weakness of the muscles of the arms and hands, more marked on the left side; moderate weakness and spasticity of the muscles of the lower extremities, more on the left side; exaggerated deep reflexes, more on the left than on the right; bilateral ankle clonus; bilateral Babinski sign; sensory disturbances of irregular distribution (fig. 15); clumsy movements of the hands; tenderness of the upper cervical spine; herpetic eruption in the eleventh dorsal dermatome. Among the diagnostic possibilities considered were: atypical multiple

sclerosis; combined funicular myelopathy; subacute diffuse myelitis, and a neoplasm high in the cervical cord. The Wassermann tests of the blood and the cerebrospinal fluid were negative.

Manometric Readings.—Examination gave the impression of a partial subarachnoid block. The readings were: initial pressure, 180 mm.; on coughing, 200 mm.; on straining, 220 mm.; on jugular compression, 300 mm.; the return to the base was somewhat delayed. The patient was given a few injections of typhoid

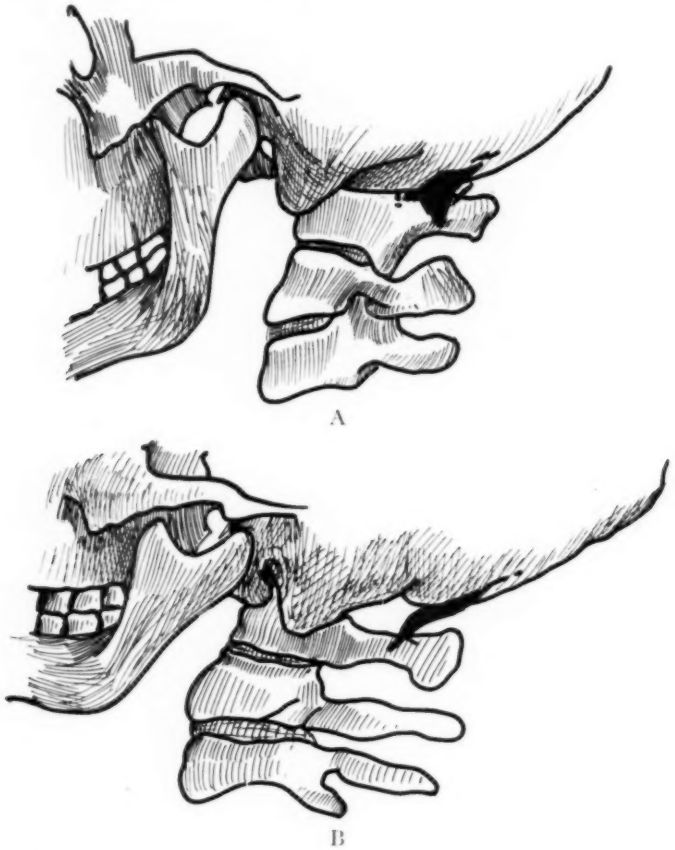

Fig. 16 (case 7).—Iodologram (tracings). *A*, half hour after the injection of the iodized oil; *B*, twenty-four hours after the injection of the iodized oil.

vaccine in the belief that the lesion was inflammatory in character, but as the condition grew steadily worse it was decided that iodolography was indicated to verify the existence of a compressing lesion.

Iodolography.—Iodized oil was injected by cisternal puncture. About half of the oil was arrested at the upper level of the first cervical vertebra. Distal to this, within the canal and reaching down to the sixth cervical vertebra, globules, variable in size, were retained. The other half of the oil dropped down to a normal level in the culdesac. Twenty-four hours later, some of the oil remained in the same location (fig. 16, *A* and *B*). A diagnosis of a high cervical neoplasm was then definitely made.

Laminectomy.—An extramedullary tumor at the first and second cervical segments, projecting through the foramen magnum dorsally and to the left, was removed. The tumor had caused marked compression of the cord (fig. 17). A stormy convalescence was followed by a good recovery.

Comment.—The precipitate onset and exceedingly rapid unfolding of the clinical picture, with the accompaniment of an erythematous eruption, justified the early suspicion of an inflammatory lesion of the cord. The character of the sensory disturbance and the distribution of the muscular involvement were not typical of a neoplasm of the spinal cord.

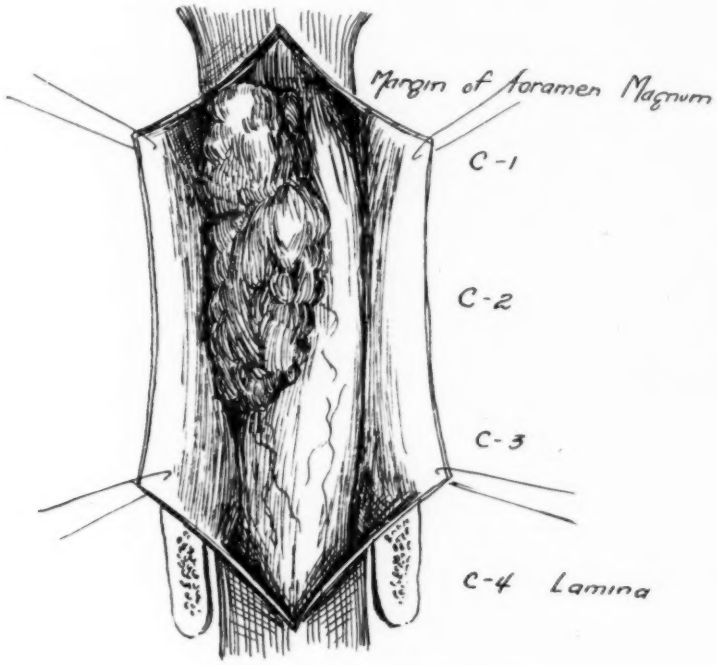

Fig. 17 (case 7).—Tumor in situ.

The manometric readings were not convincing. The iodolography was of great service in this case, for it pointed with greater accuracy to the level and nature of the lesion. The results of the laminectomy serve as further evidence of the usefulness of iodolography. A word of warning must be said against a too hasty interpretation of such iodolographic pictures, for there are instances in which similar iodolographic manifestations are present with apparently normal cords or instances in which, in the presence of leptomeningeal adhesions, similar partial blocks in the cervical region occur.

CASE 8.—*History.*—R. H., a woman, aged 32, for seven years had complained of severe headache. At the end of that period, the pain began to radiate to the

back of the neck and into the left arm. Recently, there had developed weakness, numbness and a tingling sensation in the left arm.

Examination.—Slight paresis of the left leg, left arm and shoulder girdle was present. There were moderate atrophy of the intrinsic muscles of the left hand; slight increase in the deep reflexes on the left side; a positive Hoffmann sign on the left side, and absent abdominal reflexes and sensory changes (fig. 18).

Manometric Readings.—Examination indicated a partial block. The readings were initial pressure, 130 mm.; on straining, 230 mm. (a fall in five seconds); on coughing, 500 mm. (a fall in twenty seconds). The fluid was clear but definitely xanthochromic. A diagnosis of extramedullary neoplasm involving the upper cervical segments was made.

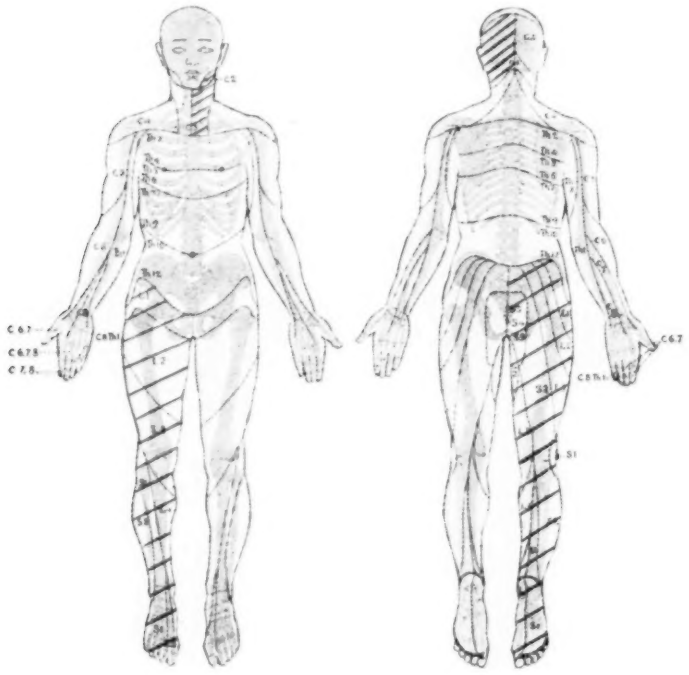

Fig. 18 (case 8).—Sensory chart.

Iodolography.—Iodized oil was injected by cisternal puncture. When the needle was passed through the ligament, resistance was felt. The spinal fluid obtained was bloody. In view of this, and in the belief that the resistance was caused by a tumor, it was thought that 0.5 cc. of iodized oil was all that could safely be injected. Almost all of the iodized oil descended to the culdesac. Only a few globules were held at the second and third cervical, and the fourth and fifth lumbar vertebrae. In spite of the negative iodologram, a high cervical neoplasm was considered as the most probable diagnosis.

Laminectomy.—An extradural meningioma in the upper cervical region, extending into the posterior cranial fossa was found (fig. 19), and was removed. The patient passed through an uneventful convalescence and made a good recovery.

Comment.—The negative iodologram is to be explained by the high location of the tumor, the injecting needle touching its lower end and entering a free subarachnoid space below the obstructive lesion.

GROUP II: PRIMARY VERTEBRAL TUMORS COMPRESSING THE SPINAL CORD

These cases constitute a small group, as this form of tumor is somewhat rare. It includes one chondroma, a chondro-osteosarcoma and a

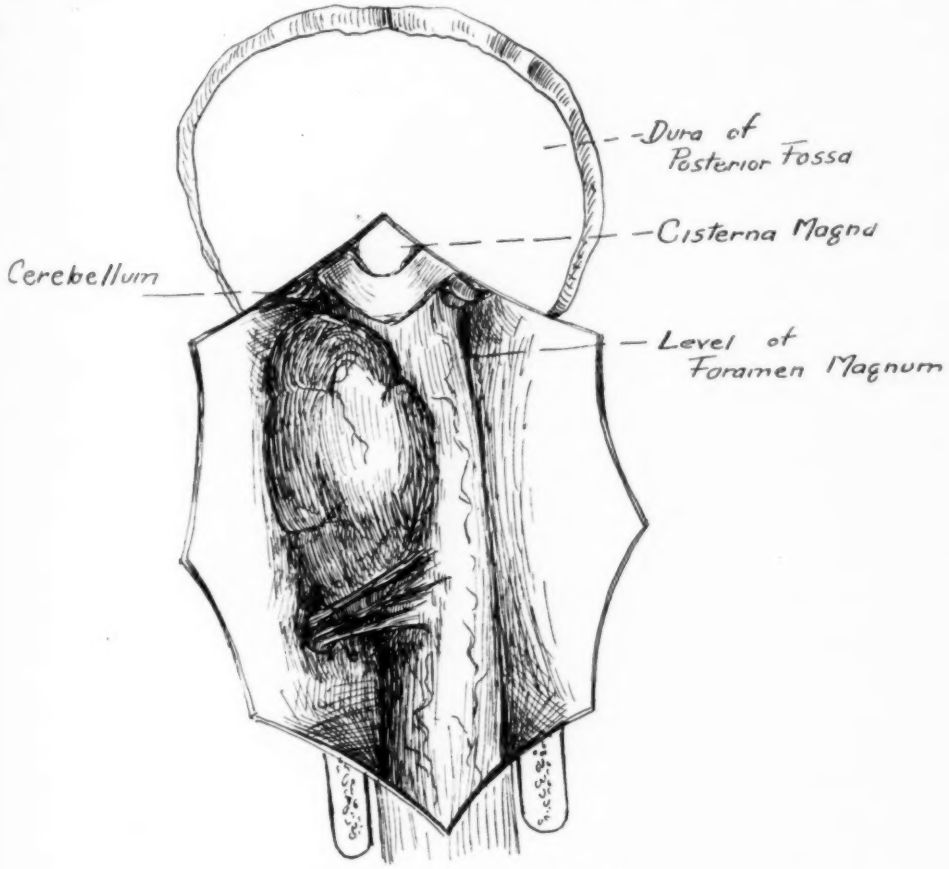

Fig. 19 (case 8).—Tumor in situ.

sarcoma. The indication for iodolography in such instances is clear, for roentgenologic examination of the spine commonly reveals no evidence of bone destruction—in the presence of evidence of compression of the cord with uncertain level symptoms—and some more precise method for determining the location of the lesion is demanded. However, even iodolography may fail in this respect. These tumors, probably by virtue

of their location on the anterior aspect of the cord and because of their solid consistency and regularity of outline, do not obliterate the subarachnoid space; they therefore permit free movement of the fluid in the space.

ILLUSTRATIVE CASES

CASE 9.—*History.*—S. Y., a woman, aged 27, suddenly developed pain in the left buttock eleven weeks previous to admission to the hospital. This was soon followed by a sensation of pins and needles, and progressive loss of power in both lower extremities. Two weeks later, she developed complete paralysis of both legs, incontinence of urine and obstinate constipation.

Examination.—There were: complete flaccid paraplegia; absent abdominal, patellar and achilles reflexes; diminution of all forms of sensation from the sixth

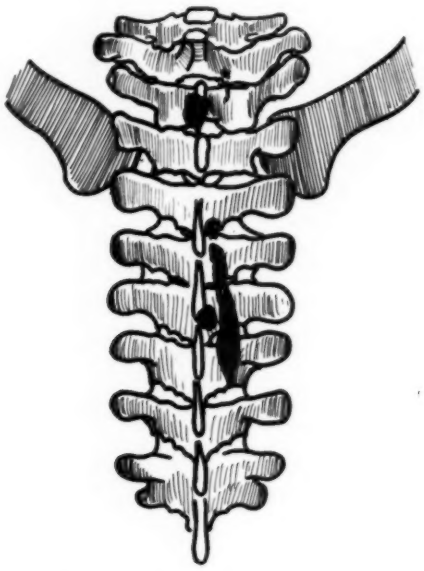

Fig. 20 (case 9).—Iodologram (tracing).

to the eighth dorsal level, and loss of all forms of sensation below the eighth dorsal level.

Manometric Readings.—Examination indicated a partial subarachnoid block. The readings were: initial pressure, 80 mm.; on coughing, 120 mm.; on straining, 160 mm.; on jugular compression, 100 mm.; the rise was slow. The fluid was a dirty gray and contained 204 cells. Because of the partial block and the pleocytosis, a diagnosis of transverse myelitis with the lesion at the sixth or seventh dorsal level was made. An intraspinal tumor was not definitely ruled out.

Iodolography.—Iodized oil, injected by cisternal puncture, demonstrated a complete block at the fourth dorsal vertebra (fig. 20). Most of the oil took a linear shape, 1½ inches (3.7 cm.) long and ½ inch (1.2 cm.) wide, on the right side. Three droplets, the size of a pea, were situated over the first dorsal, third dorsal and fourth dorsal vertebra, respectively.

Laminectomy.—The lamina of the sixth dorsal vertebra was found very vascular. At that level a soft extramedullary tumor, adherent to the bone, was found. No attempt was made to remove it. The tumor was later reported to be an osteosarcoma. After an uneventful convalescence, the patient was discharged unimproved. She was admitted to another hospital, where she slowly declined and died.

Comment.—The iodolography was of service not only in confirming the localization of the lesion but in the differential diagnosis.

CASE 10.—*History.*—M. C., a man, aged 55, six weeks before admission to the hospital, following a violent twist of the body, developed pain in the left hip and ankle.

Examination.—Active deep reflexes; an equivocal plantar reflex on the left side; bilateral Lasègue and Patrick signs more marked on the left than on the right; tenderness over the left sacro-iliac joint; a belt of hyperesthesia at the twelfth dorsal and first lumbar levels, and a mild diminution of pain and temperature sense in the first sacral dermatome on the left side were found.

A diagnosis of sacro-iliac disease with symptomatic sciatica was made; arachnoiditis or an extramedullary tumor was also considered.

The patient was given a series of epidural injections without beneficial results.

Manometric Readings.—Lumbar puncture showed a subarachnoid block. The readings were: initial pressure, 140 mm.; on coughing, 150 mm.; on straining, 150 mm.

Iodolography.—Iodized oil, injected by cisternal puncture, was found arrested at the fifth lumbar vertebra; a few globules were scattered at the third and fourth lumbar vertebrae, extending out for a distance beyond the vertebrae on the left side. On the following day, a fairly large collection of oil was found at the level of the third lumbar vertebra, considerably displaced to the left side, probably along a nerve sheath (fig. 21).

Laminectomy.—A diffuse osteoid growth (osteochondroma) was found on the posterior surface of the body of the second lumbar vertebra. It presented a well defined projection. It could not be removed. Iodized oil was found gathered above the angulation. The patient passed through an uneventful convalescence and made a fair recovery. When reexamined six months later, he was free from pain but was otherwise unchanged.

Comment.—This case presents complete harmony between the manometric readings and the iodolographic manifestations. Until the former was done, the diagnosis of tumor was much in question.

CASE 11.—*History.*—L. K., a woman, aged 47, complained of mild pain in the left shoulder for two years. One month prior to admission to the hospital, the pain in the left shoulder became more intense. At the same time weakness in the right ankle developed, and soon spread to the right leg. Soon after, pain appeared also in the left leg. The left foot felt cold and clammy. The symptoms progressed in severity so that she was soon unable to walk.

Examination.—There were: weakness of the right arm and leg (the leg more than the arm); active knee jerks and achilles reflexes (the right more than the left); right ankle clonus; right Babinski sign; absent abdominal reflexes (except the left lower); right Hoffmann sign; a zone of hyperalgesia at the second cervical

level, and hyperesthesia alternating with analgesia below the zone on the left side. Atrophy of the dorsal intrinsic muscles of the right hand was present. There was a Horner syndrome on the right.

A high cervical tumor was suggested as the diagnosis.

Manometric Readings.—Examination did not indicate a subarachnoid block. The readings were: initial pressure, 140 mm.; on coughing, 220 mm.; on straining, 450 mm.; on jugular compression, 500 mm. The fluid was normal in all its phases.

Iodolography.—Iodized oil was injected by cisternal puncture; a few globules were arrested in the region of the fourth, fifth and sixth dorsal vertebrae.

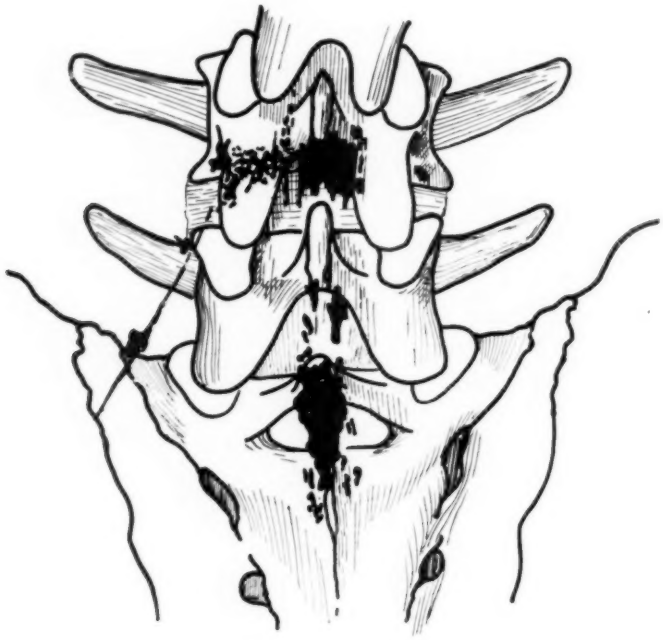

Fig. 21 (case 10).—Iodologram (tracing).

Laminectomy.—A ventral extradural chondroma was found at the level of the fifth and sixth cervical and part of the seventh cervical vertebrae (fig. 22). The absence of a manometric block is frequent in this type of tumor (Elsberg). A considerable amount of tumor was removed. The patient convalesced rapidly until one day, while sitting in a chair, she suddenly collapsed and died within fifteen minutes.

Comment.—This is one of the few instances in which iodized oil and manometric tests failed to add to the information obtained from the clinical signs. Exploration was the only avaliable means for arriving at a correct diagnosis.

GROUP III: INTRASPINAL EXTRADURAL TUMORS

This miscellaneous group of intraspinal extradural tumors includes two instances of secondary malignant disease and one instance of intraspinal neurofibroma as part of von Recklinghausen's disease.

ILLUSTRATIVE CASES

CASE 12.—*History.*—J. W., a woman, aged 57, two months before the onset of the present illness, had had an attack of what was diagnosed as pleurisy. She had not felt well since. Two months before admission to the hospital, she suddenly developed pain in the middorsal region of the spine. This was diagnosed at first

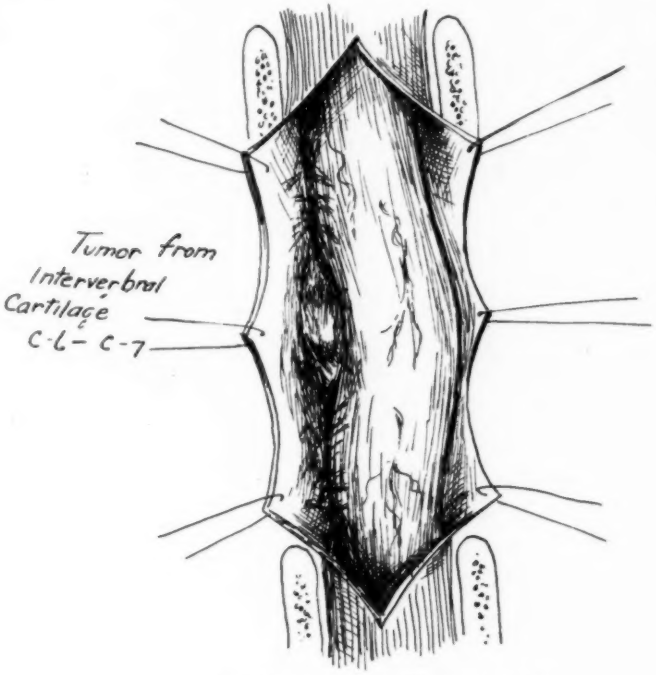

Fig. 22 (case 11).—Tumor in situ.

as spondylitis. She grew weak and was confined to bed. Three days before admission, she became paralyzed and lost sensation in both legs. She was unable to void and became obstinately constipated. The temperature rose to 101 F. During the past four months she had lost 30 pounds (13.6 Kg.) and had developed decubital ulcers.

Examination.—Examination showed flaccid paralysis of both lower extremities; absent abdominal reflexes; absent knee and ankle jerks; an equivocal plantar reflex on the left side; atrophy of the left leg; localized kyphosis and tenderness over the spines from the fifth to the tenth dorsal vertebrae; a zone of hyperalgesia from the fourth to the sixth dorsal dermatome, and loss of all forms of sensation below the sixth dorsal. A provisional diagnosis of transverse myelitis secondary to Pott's disease was made. Roentgenograms of the chest and spine were normal, except for a moderate degree of spondylitis.

Manometric Readings.—Examination suggested a partial subarachnoid block. The readings were: initial pressure, 220 mm.; on coughing, 240 mm.; on jugular compression, 240 mm. The fluid was clear but xanthochromic, and contained 3 cells.

Iodolography.—The oil was partially arrested at the seventh dorsal vertebra (fig. 23); some of it descending into the culdesac.

Laminectomy.—The laminae of the eighth, ninth, tenth and eleventh dorsal vertebrae were found to be the seat of a malignant process which extended into the enveloping musculature. The diseased tissue protruded into the intraspinal canal.

The patient died in surgical shock. The tumor was later reported as a metastatic hypernephroma.

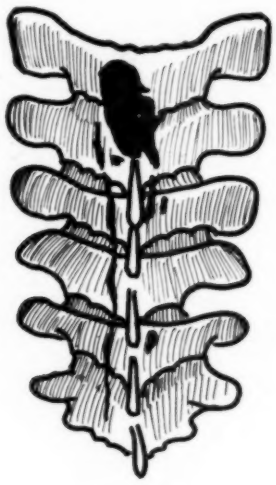

Fig. 23 (case 12).—Iodologram (tracing).

Comment.—The partial block indicated by manometric readings was corroborated by the iodologram. The latter, though somewhat irregular, was nevertheless of a character indicating the presence of a compressing lesion. It mapped out the level definitely, but failed to show the extradural location of the tumor.

Case 13.—*History.*—F. G., a woman, aged 21, two weeks before admission to the hospital suddenly became aware of a sticking, shooting pain in the left thigh. The pain radiated up and down the leg. She could no longer support herself on that leg and fell to the floor. She remained in bed; the weakness in the left leg progressed, and she became obstinately constipated and began to experience difficulty in urination.

Examination.—There were: acromegalic features; many pedunculated yellowish tumor masses (skin lesions typical of von Recklinghausen's disease had been noted two years previously); a large round mass in the back in the region between the third and eighth dorsal vertebrae (fig. 24); palpable masses in the abdomen;

mental dulness; rotary nystagmus to the left; paresis of the right abducens nerve; left facial weakness; bilateral weakness of the lower extremities; knee jerk on the left, absent, on the right, active; ankle jerk on the left, absent, on the right, active; abdominal reflexes, absent; bilateral Babinski sign; athermesthesia, hypalgesia and loss of vibratory sense below the fourth dorsal level.

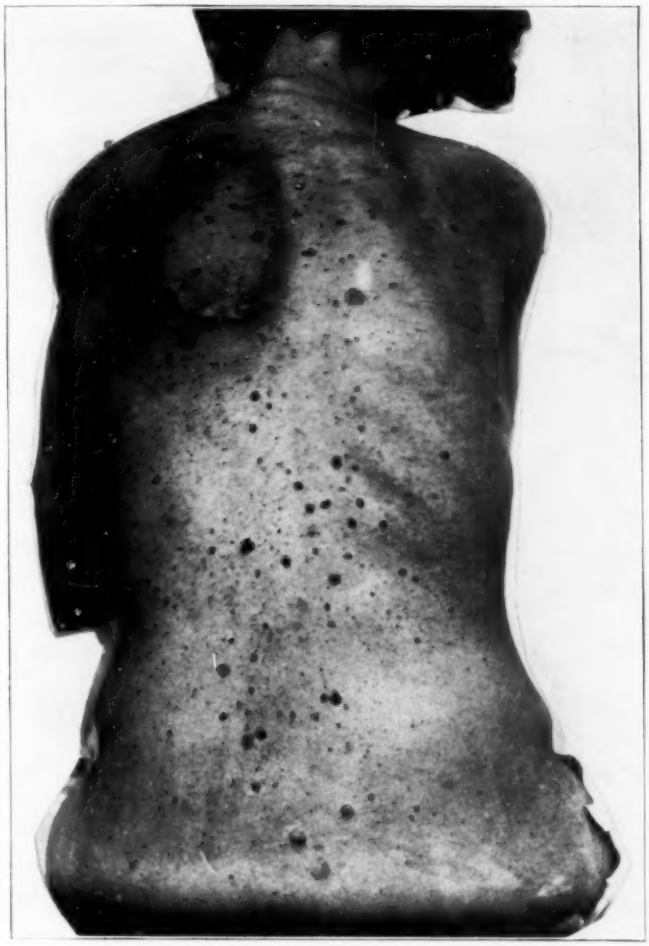

Fig. 24 (case 13).—Skin lesion and tumor.

Diagnosis.—Compression myelitis at the third and fourth dorsal vertebrae due to a tumor in the back was the diagnosis made. No manometric readings were obtained.

Iodolography.—The oil was arrested at two levels: at the third dorsal and at the sixth dorsal vertebrae (fig. 25). None of the oil reached the normal level in the culdesac. The large round mass in the dorsal region on the left was reported as definitely involving the vertebral margin of the eighth left rib, destroy-

ing the rib without expanding it. This appearance strongly suggested a malignant process.

Biopsy.—A subcutaneous nodule and pieces of the tumor were removed and were reported as a possibly malignant fascial sarcoma.

The patient declined gradually and died four months after admission.

Necropsy.—A large tumor mass about the size of a large cocoanut protruded beneath the skin of the back on the left side, and extended from about the level of the fourth to that of the ninth rib, invading the ribs so that they were included in the neoplastic tissue. The bodies of the sixth and seventh thoracic vertebrae were partially eroded by the tumor. The tumor was firm and penetrated the

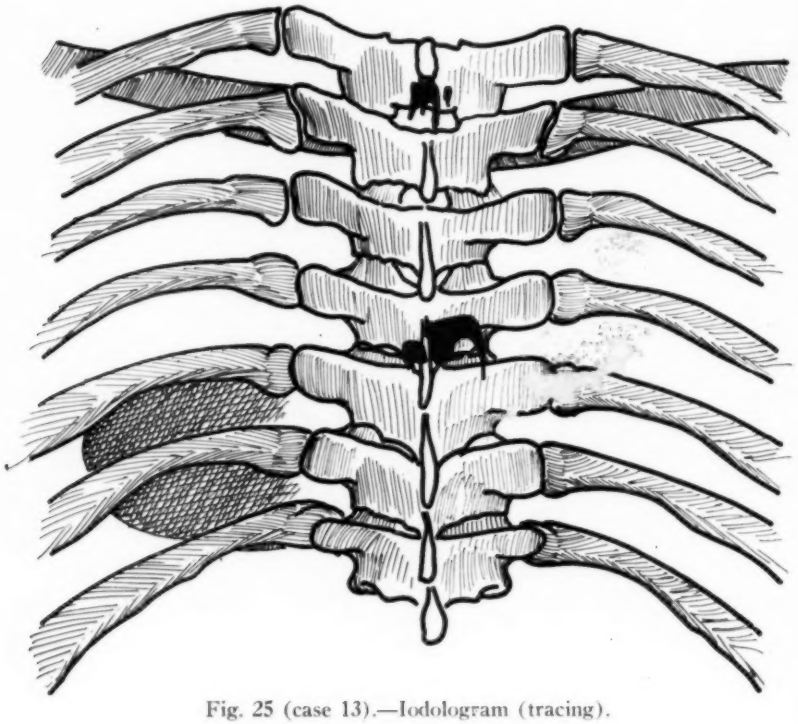

Fig. 25 (case 13).—Iodologram (tracing).

thoracic cavity on the left side. The pedicle of the tumor passed through a spinal foramen and appeared to spring from the roots of the spinal cord on the left side, at the level of the fifth and sixth dorsal vertebrae. In this region the spinal cord was markedly compressed and softened, but was apparently not invaded by tumor tissue (fig. 26). Several tumefactions were found on two branches of the brachial plexus. A search for the cause of the upper block indicated by the iodized oil did not reveal any gross alteration. Microscopic sections of the cord directly above the level of the lower block showed no inflammatory changes in the pia-arachnoid. This is significant, since claims are being made that iodized oil provokes distinct inflammatory changes in the pia-arachnoid.

Comment.—In this instance, iodolography was performed as an adjuvant to the diagnosis rather than as a necessity.

GROUP IV: INTRAMEDULLARY TUMORS OF THE SPINAL CORD

In this group is a relatively large number of cases, of which only three were verified by laminectomy. Two illustrative clinical histories of the latter type are given in detail, while the observations in seven

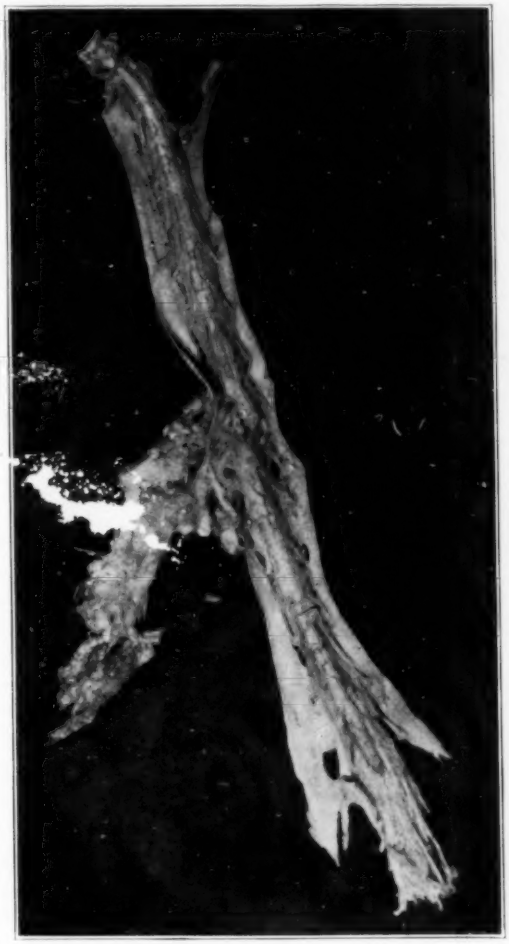

Fig. 26 (case 13).—Spinal cord and tumor.

other cases are summed up in table 1. It will be noted that iodolography is of value only in excluding in some instances the presence of an operable extramedullary tumor or in indicating the area of maximum expansion of the cord. It will also be seen that there is no characteristic iodologram which may be regarded as indicating an intramedullary tumor of the spinal cord.

ILLUSTRATIVE CASES

CASE 14.—*History.*—H. A., a man, aged 55, four years prior to admission to the hospital suddenly developed pain in the right lumbar region. It was sharp and knifelike in character, continued for a period of hours, and was followed by swelling of the legs and abdomen. The swelling subsided slowly, and he was apparently restored to health. He remained well for the next two years, complaining only occasionally of pain in the right lumbar region. Ten months before

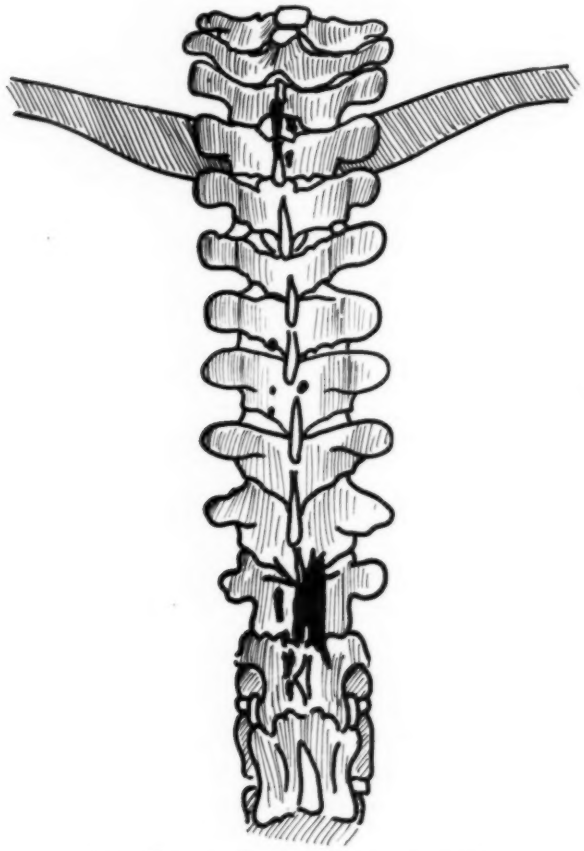

Fig. 27 (case 14).—Iodologram (tracing).

admission, the pain suddenly recurred, now in both lumbar regions, and was again sharp and knifelike; it traveled down the inner side of the thighs. The attack lasted for two days and was accompanied by difficulty in urination, obstinate constipation and swelling of the ankles.

Examination.—There were: mild bilateral paresis of the lower extremities; diminished right knee jerk; absent ankle jerks; slight bilateral atrophy of the quadriceps groups; a bilateral Lasègue sign; tenderness on percussion of the lower dorsal and lumbar spines; diminution of pain and temperature sense in the perianal region; impaired vibratory sense over the malleoli and sacrum, and a xantho-

TABLE I.—*Observations in Cases of Intramedullary Neoplasm*

	Neurologic Observations	Manometric Readings	Iodolography	Comments
Case 16 M. B. Man Aged 23	Knee and ankle jerks hyperactive, right more than left; bilateral ankle clonus; bilateral Babinski sign; sensory changes in the distribution of the second to the fifth lumbar segment	Initial pressure..... 130 mm. Coughing pressure..... 260 mm. Straining pressure..... 260 mm. Jugular compression..... 420 mm. The cerebrospinal fluid was normal in all its phases	The iodized oil descended to normal level	Clinical diagnosis of intramedullary tumor because of the history of girdle sensation, the lack of signs of root irritation, the marked involvement of the bladder and slight paretic manifestations
Case 17 D. S. Man Aged 45	First admission: unsteady gait; bilateral external rectus weakness; generalized hyperreflexia; right ankle clonus; right Babinski sign; bilateral Hoffmann sign; diminution of pain and temperature sense from eighth dorsal level; second admission: weakness of both hands; sensory changes; (see chart fig. 30); generalized hyperreflexia; bilateral equivocal plantar reflexes	Initial pressure..... 120 mm. Coughing pressure..... 200 mm. Straining pressure..... 240 mm. Jugular compression..... 200 mm. Rise was delayed; slight block	No block.....	Exclusion of extramedullary process demanded by the presence of sensory disturbances and possible cord compression, as suggested by manometric readings
Case 18 H. L. Man Aged 51	Paresis of left lower extremity; absent abdominal reflexes; hyperactive knee erks, right more than left; hyperactive achilles jerks, right more than left; Babinski sign on left side; hypalgesia from fourth to twelfth dorsal level; analgesia from twelfth dorsal to fifth sacral; vibratory sense diminished below the anterosuperior processes	Initial pressure..... 125 mm. Coughing pressure..... 145 mm. Straining pressure..... 245 mm. Jugular compression..... 2 0 mm. Rise slow; partial subarachnoid block	On the first day there was a small collection of oil at fourth dorsal vertebra; on the following day, it had descended to the normal level	Diagnosis before iodolography: extramedullary tumor. Final diagnosis: intramedullary tumor
Case 19 Man Aged 38	Weakness of the left lower extremity; loss of pain and temperature sense in the left lower extremity; diminished upper abdominal reflexes; hyperactive knee jerks, left more than right; diminished achilles jerks; diminution of the sense of touch and vibration in the left lower extremity	Initial pressure..... 140 mm. Coughing pressure..... 260 mm. Jugular compression..... 450 mm. No block	No block.....	Intramedullary cord neoplasm or vascular lesion diagnosed clinically
Case 20 G. K. Woman Aged 44	Weakness of right arm and both legs; active upper abdominal reflexes, right more than left; absent left lower abdominal reflex; active knee jerks, left more than right; diminished left and absent right ankle jerk; Babinski sign on the left; atrophy of the right leg; pain and temperature sense diminished on right side from eighth cervical down; the cerebrospinal fluid contained eight cells, otherwise was normal	Initial pressure..... 120 mm. Coughing pressure..... 180 mm. Straining pressure..... 410 mm. No block	Negative; a few droplets arrested in the mid-dorsal region	Intramedullary disease—the clinical diagnosis
Case 21 M. P. Man Aged 46	Paresis of right arm and leg; knee and ankle jerks active but unequal, right more than left; bilateral Babinski sign; slight atrophy of muscles of the right leg; marked atrophy of deep back muscles and of instrinsic muscles of both hands; hypalgesia on the left from second or third cervical down; impaired vibratory sense on the right side	Initial pressure..... 80 mm. Coughing pressure..... 120 mm. Straining pressure..... 100 mm. Jugular compression..... 240 mm. The rise and fall was rather slow; partial block	The iodized oil descended rapidly into the cul-de-sac	Syringomyelia diagnosed before iodolography was performed
Case 22 J. H. Man Aged 58	Irregular and unequal pupils, left more than right; pupils react sluggishly to light; Horner's syndrome on the left; weakness of all muscle groups of the left upper extremity, including the muscles of the shoulder girdle; bilateral sensory changes; Wassermann reaction of the spinal fluid negative	Manometric readings normal	Iodolograms normal.....	Course of deep roentgen therapy to the spine; patient improved considerably on discharge, having regained considerable power in the left upper extremity; provisional diagnosis of syringomyelia made

chromic cerebrospinal fluid which coagulated rapidly. A diagnosis of a lesion of the cord extending from the eighth to the tenth dorsal level was made.

Manometric Reading.—Studies of the cerebrospinal fluid were not made because lumbar puncture yielded only a small quantity of fluid which immediately coagulated.

Iodolography.—A few small globules were arrested at the level of the second and third dorsal vertebrae. The bulk of the iodized oil was arrested at the level of the eleventh dorsal vertebra, mainly on the right side of the canal (fig. 27). Twenty-four hours later, the iodized oil was found at the same level. This picture was interpreted as indicating an intramedullary neoplasm.

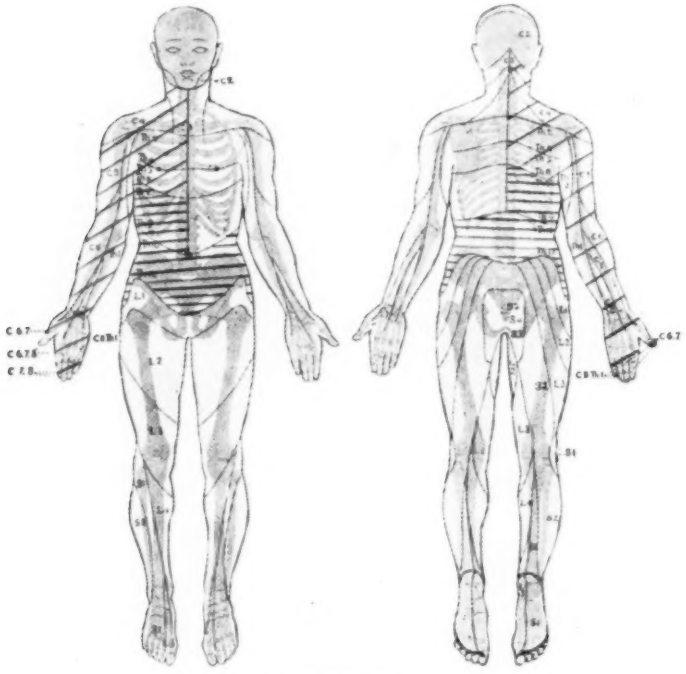

Fig. 28 (case 15).—Sensory chart.

Laminectomy.—The eleventh and twelfth dorsal vertebrae were removed. The exposed dura was tense. The pia-arachnoid was adherent to the swollen cord. The latter was yellowish red in appearance, and the vessels on its surface were dilated. The cord felt cystic and on aspiration yielded a straw-colored yellow fluid. The postoperative diagnosis was an intramedullary neoplasm. Roentgenotherapy was given. The vesical control returned, but the other neurologic symptoms remained unchanged.

Examination four months later revealed no change in the objective signs.

Comment.—The value of the iodologram in this instance was not only in the establishment of a definite level, so that the laminectomy was done with the removal of only two vertebrae, but also in that it indicated the intramedullary location.

CASE 15.—*History.*—H. H., a woman, aged 19, came to the hospital for the first time complaining of attacks of vomiting and of pain in the right side of the neck, of three weeks' duration. At this time, examination revealed: right exophthalmos; horizontal and vertical nystagmus; scoliosis and kyphosis with deformity of the pelvis, and hyperactive deep reflexes. The case was regarded as one of multiple sclerosis or some other organic lesion of the cerebrospinal axis.

At the second admission to the hospital, one year later, the patient complained of more constant and more intense pain, stiffness of the back, obstinate constipation and difficulty in urination.

Fig. 29 (case 15).—Iodologram (tracing).

Examination.—Paresis of the upper extremities (the right arm was weaker than the left); absent right pectoral, biceps, and radial reflexes; transient patellar clonus; a Babinski sign on the right side; a Chaddock sign on the left; absent abdominal reflexes; loss of muscle and tendon sense in the left big toe; diminution of all forms of sensation from the third rib down, and diminution of vibratory sense in the lower extremities were found. Changes in cutaneous sensibility were present, as shown in figure 28.

Manometric Readings.—The readings were: initial pressure, 200 mm. with rapid rise and fall; no block. The fluid was xanthochromic, and contained an increase in globulin. A note by Dr. Elsberg, which summed up the diagnostic possibilities, reads as follows: "The marked sensory disturbances over the lower chest and upper abdomen are due to root compression from the marked curvature of the spine. The other neurologic disturbances are mainly, if not entirely, due

to a lesion at about the fourth to sixth cervical segments of the spinal cord, more on the left than on the right side.

"In spite of the negative manometric test, the presence of xanthochromia and increase of globulin point to a compression of the spinal cord. I think this patient has a dural or an extradural lesion, either a new growth or a pachymeningitis cervicalis hypertrophica. There is some support for this latter diagnosis. This is a case in which the manometric test should be repeated with great care and I believe that much information would be gained from a lipiodol injection. The fact that the patient has nystagmoid jerks especially to the right does not negative the diagnosis of a high cervical lesion but rather supports it.

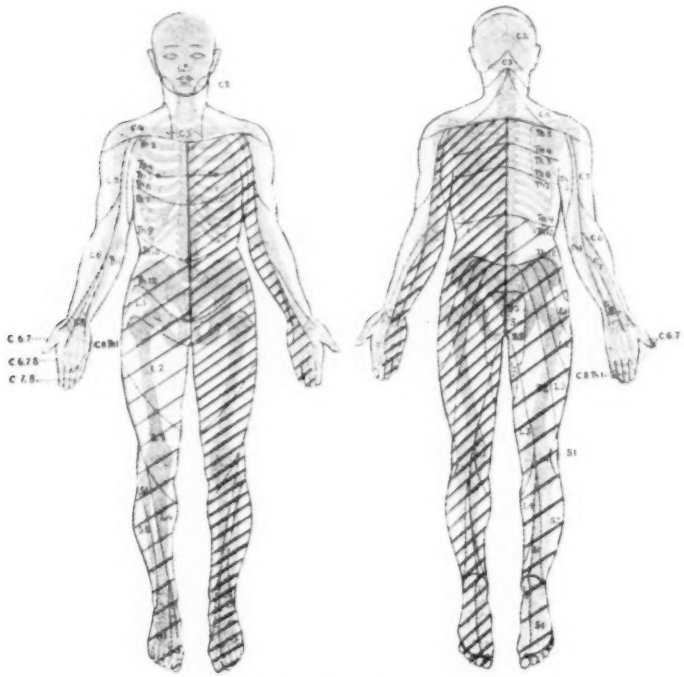

Fig. 30 (case 17).—Sensory chart.

"The marked kyphoscoliosis is an old change possibly due to a poliomyelitis in infancy or childhood, and I believe is not the cause of the present symptoms although it adds much to complicate the clinical picture. It is my impression from the study of the x-ray plates, although I have been unable to convince the roentgenologists of the fact, that there is an enlargement of the cervical canal at the level of the third to sixth cervical vertebrae."

Iodolography.—The oil was arrested at the level of the third cervical vertebra (fig. 29), being distributed on both sides of the intraspinal canal in domelike fashion. Twenty-four hours later, some oil had descended to the eighth dorsal vertebra and had also distributed itself along the sides of the canal from the first cervical to the eighth dorsal vertebra, some of the oil having descended to the culdesac. The spinal canal appeared widened. Following the injection of iodized oil, there appeared an increase in the bladder and rectal difficulties.

Laminectomy.—The spinal laminae of the fourth, fifth and sixth cervical vertebrae were removed; the exposed cord was found enlarged; the vessels on the surface were irregular, as is seen in an intramedullary lesion; the cord was soft and cystic. The cord was punctured; 15 cc. of reddish-yellow fluid was withdrawn; after that, the exposed part of the cord collapsed.

The postoperative record reads as follows: "It is fair to conclude that the patient is suffering from a syringomyelia with cavity formation and that a greater part of the cord than the part exposed at the operation is involved. The fluid obtained by puncture is slightly bloody and it is probable that slow bleeding has been occurring into a cavity in the cord and that the progressive symptoms are

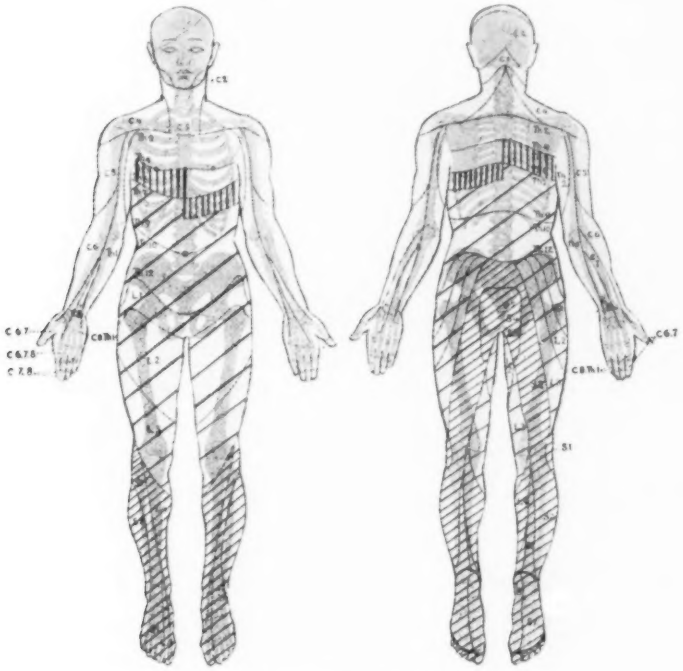

Fig. 31 (case 23).—Sensory chart.

due in part to the advancing disease of the cord. Whether the intramedullary disease is secondary to the old trauma in childhood and an ensuing scoliosis, or whether the entire condition is one and the same process, i. e., a syringomyelia (in which scoliosis frequently occurs), cannot be stated with certainty. It is my feeling that the trauma which the patient sustained in her fourteenth year was not the cause of the scoliosis, but that the patient has had from the beginning a syringomyelia to which the curvature of the spine was secondary, and that the spinal deformity became so extreme that it was for many years the most prominent symptom."

Comment.—In this instance, the iodogram unquestionably solved a difficult diagnostic problem.

GROUP V: PACHYMENINGITIS

In this group, we had only one case. It presented features of a transverse myelitic process. Iodized oil was injected to establish the presence or absence of an intraspinal compressing agent.

CASE 23.—*History.*—L. P., a boy, aged 13 years, aside from having the common diseases of childhood without apparent sequelae, was well up to the age of 10 years and free from symptoms until one morning when he suddenly found himself unable to move his legs and felt pain in the spine. The paralysis in the legs was

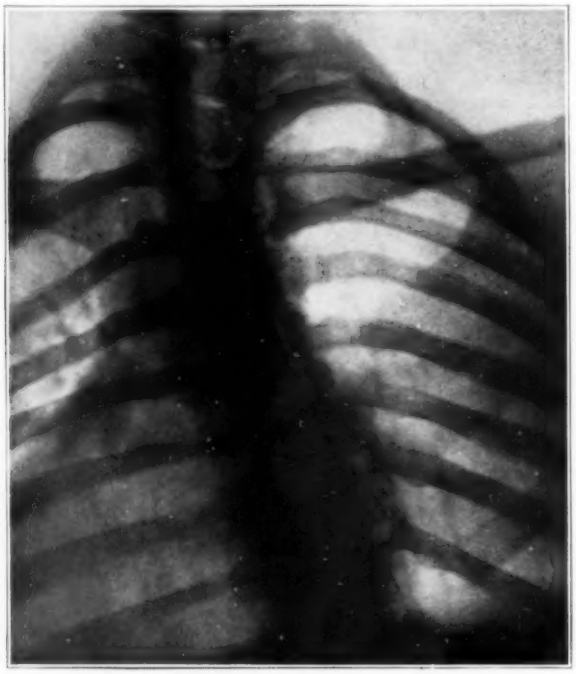

Fig. 32 (case 23).—Iodologram.

flaccid. Pott's disease was suspected, and he was placed in a cast. There was no return of power, and two years later he began to lose sensation in the legs.

Examination.—Three years after the onset of the illness, examination revealed: spastic paraplegia; loss of abdominal and cremasteric reflexes; hyperactive knee jerks and ankle jerks; bilateral Babinski sign; pain, temperature and touch sense diminished from the sixth dorsal dermatome down (fig. 31); vibration and joint sense lost from the same level down.

Iodolography.—Iodized oil was introduced by cisternal puncture. It was found arrested at the sixth dorsal vertebra (fig. 32).

Laminectomy.—The residuals of an old Pott's disease with chronic pachymeningitis and new bone formation were disclosed at the operation. The patient recovered from the operation but did not regain any of the lost functions.

Comment.—It is of interest to note the character of the silhouette made by the iodized oil, which by its extent and sharp lower border may be regarded as characteristic of this type of lesion.

GROUP VI: ARACHNOIDITIS

It is claimed by several investigators that certain forms of iodized oil silhouettes may be identified as due to adhesive processes in the subarachnoid space, as in the so-called chronic arachnoiditis. The latter term is being used of late interchangeably with the older term of meningitis serosa circumscripta. In this intraspinal disease, arachnoid adhesions often form blind pockets, in which accumulations of cerebrospinal fluid are retained and cause local compression of the spinal cord; they provide signs and symptoms of tumor of the spinal cord. Instances of this type are known to occur in the wake of clinically established cases of epidemic cerebrospinal meningitis, and Nonne [6] reported two such cases in which iodolographic observations demonstrated a definite subarachnoid block. Cases are also known in which initial meningeal involvement escaped observation, leaving behind morphologic changes which later caused circumscribed chronic adhesive arachnoiditis. It is this type of lesion which is included in this group.

The clinical manifestations are not pathognomonic of the condition; the manometric estimation is only suggestive, and the iodolographic manifestations are of great service, particularly when supported by clinical observations.

From what we have to say, it will be apparent that it is not always possible to demonstrate the existence of small subarachnoid adhesions, nor is it always possible from the outline of the arrested contrasting substance to recognize with accuracy the character of the obstructing lesion. Hence, it is as yet impossible from the outline of the iodized oil block to differentiate an intraspinal tumor from an arachnoid adhesion. Once the existence of a subarachnoid block is established and the clinical picture points to the presence of a compressing intraspinal lesion, the indications for exploratory laminectomy are definite. Here it is not essential to define the lesion too accurately, once the therapeutic steps are defined.

ILLUSTRATIVE CASES

CASE 24.—*History.*—H. S., a man, aged 50, drank excessively over a long period; he sustained an injury from a fall from the ladder at the age of 36, though no serious sequels followed. He had gonorrhea at the age of 17, and typhoid at 20. Three and a half years before admission, he began to experience an itching and burning sensation on the sole of the left foot. This sensation later spread to the level of the hip. Six months before admission, he developed obstinate

6. Nonne: Presentation at the Hamburg Aertzlicher Vereins, 1925, vol. 30, p. 11; Deutsche med. Wchnschr. **52**:172, 1926.

constipation and urinary symptoms: difficulty in starting the stream with frequency, urgency and occasional overflow.

Examination.—There were: weakness of both legs, of the right more than the left; marked wasting of the muscles of the right thigh and leg; hyperactive deep reflexes on the right side; a Babinski sign on the right and an equivocal plantar reflex on the left side; exhaustable abdominal reflexes; a belt of hyperalgesia between the fourth and eighth dorsal dermatomes; below this level pain and temperature senses were disturbed on the left more in the sacral segments; on the right side pain was involved in the fifth lumbar and in all of the sacral segments. The Wassermann reactions of the blood and cerebrospinal fluid were negative.

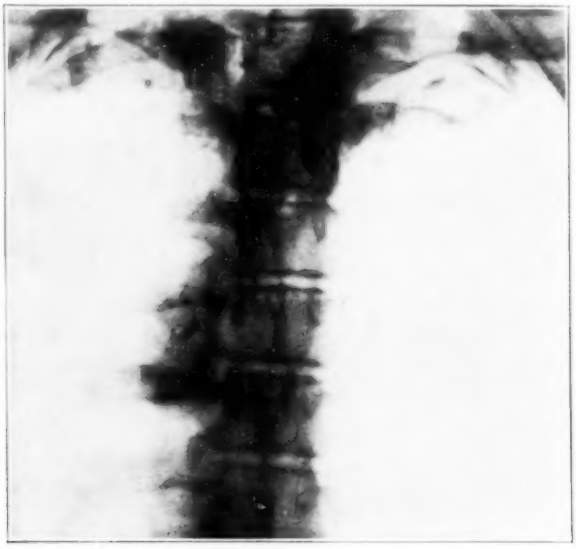

Fig. 33 (case 24).—Iodologram.

Manometric Readings.—Examination suggested a partial subarachnoid block. The readings were: initial pressure, 120 mm.; on straining, 220 mm.; on jugular compression, 200 mm. The rise and fall was rapid. The fluid was slightly yellow and contained no cells.

Iodolography.—Iodized oil, injected by cisternal puncture, was arrested totally at the third dorsal vertebra (fig. 33).

Laminectomy.—The spines and laminae of the first, second and third dorsal vertebrae were removed. When the dura was opened and a small nick made in the arachnoid, there was a profuse, free flow of spinal fluid both from above and below. A probe passed freely in all directions. There was some admixture of iodized oil with the cerebrospinal fluid.

The patient passed through an uneventful convalescence and made a good recovery.

CASE 25.—*History.*—A. C., a woman, aged 55, four weeks before admission to the hospital suddenly developed pain between the shoulder blades; at the end of

two weeks, the pain spread to the left shoulder and soon after to the right shoulder. She also began to experience difficulty in walking and developed urinary retention.

Examination.—Small and unequal pupils, the left smaller than the right; enophthalmos of the right eye; paresis of all four extremities, the weakness being more marked on the right side; hyperactive deep reflexes; bilateral Babinski sign; absent abdominal reflexes, and a zone of hyperalgesia in the third and fourth cervical segments with diminution of all form of sensation below that level were found. The cerebrospinal fluid was normal in all phases, and contained only 4 cells. The Wassermann reaction of the blood was negative.

Manometric Readings.—The readings were: initial pressure, 100 mm.; on compression of one jugular vein, no rise; on coughing, 200 mm.; on compression of both jugular veins, 102 mm.; the rise and fall was slow.

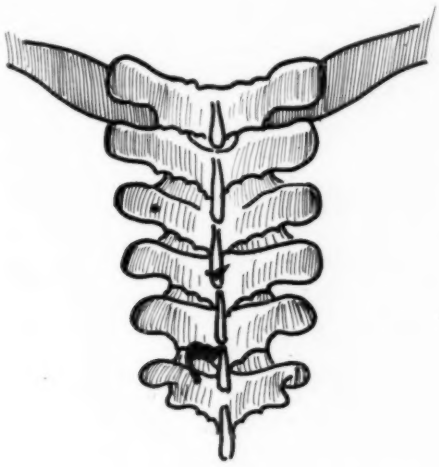

Fig. 34 (case 35, table 3).—Iodologram.

Diagnosis.—In view of a distinct level and the almost complete subarachnoid block, a diagnosis of extramedullary tumor of the spinal cord was made.

Iodolography.—Iodized oil was injected by cisternal puncture; when examination was made a half hour later, the oil was seen arrested in a diffuse manner along the lower cervical and upper dorsal vertebrae. A small amount of iodized oil was also checked in the lumbar region. Twenty-four hours later, reexamination revealed that practically all of the oil had descended from the cervical and dorsal regions to the dural culdesac. Only a small amount was still present at the level of the sixth dorsal vertebra. This atypical behavior in the descent and distribution of the iodized oil led to the following interpretation: "There is a persistent, partial block at the sixth dorsal vertebra. The contour of the iodized shadow at this level is such as is seen in arachnoiditis or an epidural lesion. In the absence of changes in the spinal column the diagnosis of arachnoiditis associated with an inflammatory or degenerative lesion of the spinal cord is most likely."

Course.—Following the iodolography, the patient was given several injections of neoarsphenamine. She soon began to improve gradually, but steadily, regaining

partial power in the extremities and full control of the bladder function. The sensory disturbances disappeared. Decubital ulcers, which were present at the height of the illness, healed.

Comment.—In this instance, the iodologram saved the patient from an exploratory laminectomy. The clinical manifestations, in spite of the acute onset and the rapid unfolding of the clinical picture, justified the diagnosis of tumor of the spinal cold. The iodologram pointed to

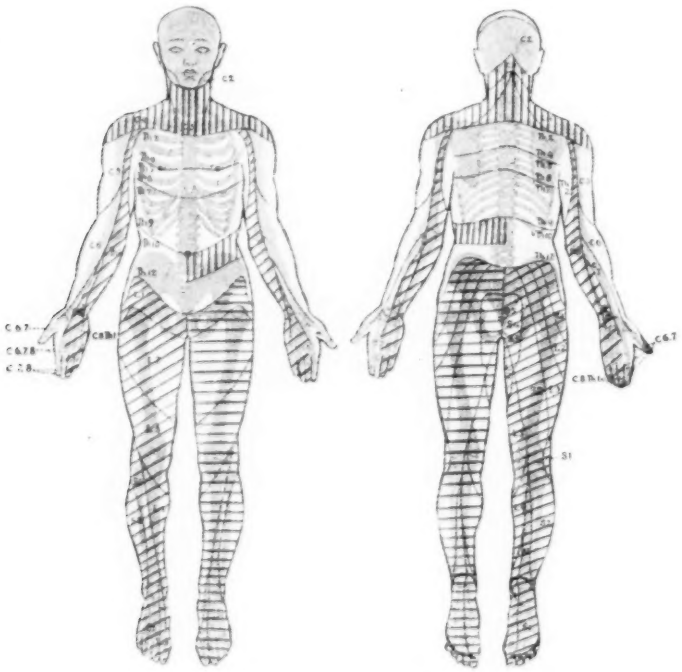

Fig. 35 (case 36, table 3).—Sensory chart.

another diagnostic possibility, and indicated therapeutic measures (in spite of the negative serologic test), such as antisyphilitic treatment, with results that speak for themselves.

GROUP VII: LUMBOSACRAL RADICULITIS (TABLE 2)

This group consists of eight cases. A perusal of their clinical features, as summed up in table 2, will reveal the reasons for and the results of iodolography. It is highly significant that in instances in which the manometric reading excluded subarachnoid block, the iodolograms corroborated the observations; in two instances, however, in which the manometric estimations indicated a partial block, the iodolograms showed a patent subarachnoid space.

TABLE 2.—*Observations in Cases of Lumbosacral Radiculitis*

	Neurologic Observations	Manometric Readings	Iodolography	Comments
Case 26 D. M. Woman Aged 64	Paraparesis; atrophy of right thigh and calf muscles; unequal abdominal reflexes, L<R; knee and achilles jerks absent on the right side; Babinski sign on the left side; hypalgesia on the left side from fifth lumbar to third sacral	Initial pressure..... 180 mm. Straining pressure..... 420 mm. Jugular compression..... 360 mm. No block	No block.....	Persistence of pain and slight sensory changes, which aroused slight suspicion of intraspinal tumor
Case 27 M. M. Man Aged 45	Tenderness over left sciatic nerve; moderate left Lasègue sign; tenderness on right sacro-iliac joint; left knee and ankle jerks diminished; hypalgesia below tenth dorsal; inconstant absent abdominal reflexes	Initial pressure..... 80 mm. Coughing pressure..... 100 mm. Straining pressure..... 500 mm. Slow fall; partial block	No block.....	Because of suspicious manometric readings, injection of iodized oil definitely ruled out intraspinal neoplasm
Case 28 S. S. Man Aged 45	Knee and ankle jerks hyperactive, right more than left; abdominal reflexes diminished on right side (scar); vibration and joint sense diminished in the right foot; tenderness in lumbar and sacral vertebrae; hypalgesia from fifth lumbar to first sacral on the right side	Initial pressure..... 310 mm. Coughing pressure..... 340 mm. Straining pressure..... 500 mm. Rise and fall prompt; no block	Bulk of iodized oil passed down to level of the middle of the body of fourth lumbar vertebra; from there down it formed, for a distance of 1¾ inches, a narrow column with projections outlining the nerve roots; upper level, rounded	Exploratory laminectomy; roots normal, no apparent lesions; condition improved after operation
Case 29 M. K. Man Aged 44	Intact motor power; diminished right ankle jerk; Lasègue on right side; tenderness over sciatic trunk; no sensory changes	Initial pressure..... 60 mm. Coughing pressure..... 80 mm. Straining pressure..... 160 mm. Jugular compression..... 180 mm. Slow rise and fall; partial block	No block.....	Three epidural injections given without relief to the patient; considered as an indication for iodolography
Case 30 M. G. Aged 40	On first admission: motor power intact; hyperalgesia from fourth lumbar to second sacral on left. On second admission: hypalgesia from fourth lumbar to first sacral on left; left ankle and left abdominal reflexes diminished; mild left Lasègue sign	Initial pressure..... 150 mm. Coughing pressure..... 180 mm. Straining pressure..... 320 mm. Jugular compression..... 340 mm. No block	No block.....	After iodolography, made rapid recovery
Case 31 L. S. Man Aged 41	Paresis of left lower extremity; knee jerks active, left more than right; Lasègue sign on left side; atrophy of left gluteal muscles; hyperalgesia from tenth to twelfth dorsal; hypalgesia in fourth lumbar to first sacral on left side	Initial pressure..... 100 mm. Coughing pressure..... 280 mm. Straining pressure..... 460 mm. Jugular compression..... 520 mm. No block	No block.....	Diagnosis rested between an extramedullary compressing lesion or an inflammation radiculitis; the latter established by normal iodolographic observations
Case 32 F. P. Aged 34	Paresis of left leg; left knee and ankle jerks diminished; left Lasègue sign; atrophy of left calf muscle; hyperalgesia in perianal region	Initial pressure..... 140 mm. Coughing pressure..... 210 mm. Straining pressure..... 360 mm. Rapid rise and fall; no block	No block (narrow outline)	Slight improvement on epidural injection
Case 33 E. W. Aged 35	Paresis of the right leg; absent abdominal reflexes; right knee and ankle jerks diminished; coccyx displaced anteriorly (x-ray); hypesthesia and hypalgesia of right leg, mainly third and fourth lumbar	Initial pressure..... 140 mm. Jugular compression..... 320 mm. No block	No block.....	Improved on administration of epidural injection

TABLE 3.—*Observations in Cases of Multiple Sclerosis*

	Neurologic Observations	Manometric Readings	Iodölography	Comments
Case 34 J. L. Aged 31	Paresis of right leg; hyperactive knee and ankle jerks; bilateral Babinski; absent abdominal reflexes; belt of hyperalgesia to seventh dorsal; hypalgesia below eleventh dorsal on left side; Brown-Sequard-like syndrome	Initial pressure..... 130 mm. Coughing pressure..... 600 mm. Straining pressure..... 400 mm. Jugular compression..... 360 mm. Slow rise and fall; partial block	A few small globules arrested at third to eighth dorsal vertebrae; and third to fourth lumbar vertebrae	Roentgen therapy; laminectomy, fifth to sixth dorsal vertebrae; no neoplasm
Case 35 M. Z. Aged 50	Rigidity of both legs; pyramidal tract sign; absent abdominal reflexes; belt of hyperalgesia, second and third dorsal; impaired vibratory and joint sense in lower extremities	Initial pressure..... 140 mm. Coughing pressure..... 200 mm. Straining pressure..... 200 mm. Jugular compression..... 260 mm. Rise and fall rapid; no block	A small quantity of the oil arrested at the seventh and eighth dorsal vertebrae; 24 hours later, some of it still held there (fig. 34)	Laminectomy disclosed a thin and wavelike outline of spinal cord
Case 36 G. B. Aged 27	Lateral nystagmus, right facial weakness, weakness of both upper extremities; wasting of intrinsic muscles of hand; ataxia in upper and lower extremities; intention tremors; complete paralysis and atrophy of both lower extremities, left more than right; hyperactive deep reflexes of muscles of lower extremities; absent abdominal reflexes; left Babinski sign; the sensory changes are shown in fig. 35	Initial pressure..... 100 mm. Coughing pressure..... 160 mm. Straining pressure..... 500 mm. No block	Several globules of oil arrested at sixth to ninth dorsal vertebrae	Typhoid vaccine; marked improvement
Case 37 S. N. Aged 38	Unequal pupils; paresis of right lower leg and atrophy of the right leg; unequal abdominal reflexes, left more than right; hyperactive knee and and ankle jerks, right more than left; bilateral equivocal plantar reflexes; hypalgesia below fourth dorsal; vibratory sense impaired below anterior superior spines; sense of touch intact	Initial pressure..... 180 mm. Coughing pressure..... 220 mm. Straining pressure..... 240 mm. Jugular compression..... 230 mm. Partial block	Partial arrest of oil at fifth and sixth dorsal vertebrae, with some fraying of the material at its lower border; on following day the iodized oil descended to the cul-de-sac (fig. 36)	Brown-Sequard-like picture strongly suggested tumor of the spinal cord; after negative iodolographic observation, the diagnosis of tumor was discarded
Case 38 J. R. Aged 31	Unequal pupils, right more than left; left facial asymmetry; paraplegia; absent abdominal reflexes; hyperactive knee and ankle jerks; bilateral Babinski sign; belt of hyperalgesia, sixth dorsal; hypalgesia, thermohypalgesia on the left side; impaired vibratory sense in lower extremities	Initial pressure..... 120 mm. Coughing pressure..... 180 mm. Straining pressure..... 200 mm. Jugular compression..... 200 mm. No block	Small globules retained in cisterna magna and in sacrum; few specks distributed through entire canal	Sensory manifestations and the duration of the symptoms aroused strong suspicion of tumor of spinal cord
Case 39 J. E. Aged 52	Nystagmus; unsteady gait; unequal knee and ankle jerks, left more than right; absent lower abdominal reflexes; pain impaired in both lower extremities involving lower lumbar and sacral segments; sensory changes not constant	Initial pressure..... 120 mm. Coughing pressure..... 180 mm. Straining pressure..... 420 mm. Jugular compression..... 360 mm. Slow rise and fall; partial block	A few small globules arrested at the seventh and ninth dorsal vertebrae	Patient left the hospital almost free of signs and symptoms
Case 40 M. S. Aged 50	Hemiplegic gait; coarse tremor of hands; tremulous speech; hyperactive deep reflexes; unequal abdominal reflexes, left more than right; hyperalgesia from fourth to fifth cervical; hypalgesia below that level on left side and bilaterally in fourth and fifth sacral	Initial pressure..... 60 mm. Coughing pressure..... 120 mm. Straining pressure..... 120 mm. Jugular compression..... 220 mm. Slow fall and rise; partial block	A few globules in cervical and upper dorsal region	The possible existence of tumor of spinal cord considered because of the sensory picture
Case 41 B. R. Aged 58	Paresis of left hand; paresis of both legs; absent abdominal reflexes; active knee and ankle jerks, left more than right; bilateral ankle clonus; left Babinski sign; atrophy of muscles of left arm and right leg; loss of sense of pain in third lumbar and fifth sacral on left side; temperature sense lost, third lumbar to fifth sacral on left side, diminished from eighth dorsal; vibration diminished from twelfth dorsal	Initial pressure..... 90 mm. Coughing pressure..... 150 mm. Straining pressure..... 400 mm. No block	A few drops arrested at seventh dorsal vertebrae	Because of sensory manifestations tumor could not be definitely excluded
Case 42 H. G. Aged 34	Paresis of both lower limbs, left more than right; absent abdominal reflexes; hyperactive knee and ankle jerks; bilateral ankle clonus; bilateral Babinski sign; hypesthesia from sixth dorsal on right and from first dorsal on left side	Initial pressure..... 100 mm. Coughing pressure..... 360 mm. Straining pressure..... 480 mm. No block	A few globules at the fifth and ninth dorsal, and at the third lumbar vertebrae	Sensory changes aroused suspicion of tumor

GROUP VIII: MULTIPLE SCLEROSIS (TABLE 3)

It is not uncommon for multiple sclerosis to present sensory manifestations that are occasionally associated with a definite sensory level. In such instances, and this is a common experience of the neurologist, the differential diagnosis is exceedingly difficult. An intraspinal tumor cannot be excluded, particularly when the manometric readings indicate a partial block. The anatomic alterations, such as arachnoid adhesions, which are responsible for such misleading occurrences, are well known.

Such reactive changes in the pia-arachnoid are not uncommonly associated with degenerative lesions of the cord, and give rise to adhesions which partially block the free flow of cerebrospinal fluid or of substances introduced into the subarachnoid space. In two cases in this

TABLE 4.—*Observations in Cases of Amyotrophic Lateral Sclerosis*

	Manometric Readings		Iodolography	Clinical History	Comment
Case 43 J. S. Child Aged 4	Initial pressure..... Coughing pressure... Straining pressure... Jugular compression Slow rise and fall	80 mm. 80 mm. 80 mm. 100 mm.	Negative	Picture of amyotrophic lateral sclerosis; gave history of diplopia and coarse tremors of entire body four years before and during recent illness	Partial subarachnoid block shown by manometric test, indicated desirability of iodolography
Case 44 J. K. Man Aged 52	Initial pressure..... Coughing pressure... Straining pressure... Jugular compression Slow rise and fall	150 mm. 220 mm. 480 mm. 420 mm.	Negative	Picture of amyotrophic sclerosis; subjective pain in lower extremities	Slow rise and fall in manometric examination suggested iodolography
Case 45 H. G.	Initial pressure..... Coughing pressure... Jugular compression No block	120 mm. 190 mm. 550 mm.	Negative	Spastic paresis of left leg; bilateral footdrop; absent left lower abdominal reflexes; hyperactive right knee jerks; absent left achilles reflexes; vague sensory disturbance from about first dorsal vertebra; bladder disturbances	Intraspinal tumor could not be entirely excluded; iodolography helped to establish the correct diagnosis

group a laminectomy was performed in spite of the fairly normal iodolograms and only suggestive manometric readings, and the absence of a tumor was verified.

GROUP IX: AMYOTROPHIC LATERAL SCLEROSIS (TABLE 4)

In these cases iodized oil was injected mainly for purposes of diagnostic corroboration and to exclude the highly improbable existence of an intraspinal neoplasm. An additional excuse will be found in the suggestive manometric readings (the slow rise and fall) in two cases, and the vague sensory manifestations in another.

GROUP X: DIFFUSE DEGENERATIVE DISEASE OF THE CEREBROSPINAL AXIS (TABLE 5)

The only justification for the use of iodolography in these instances is the exceedingly unusual clinical pictures presented by the two patients.

GROUP XI: TRANSVERSE MYELITIS (TABLE 6)

The clinical manifestations in the members of this group were such as to demand the use of every possible diagnostic means, including iodolography, in order to exclude definitely an intraspinal tumor or other compressing agent.

GROUP XII: VARICOSE (DILATED) VEINS OF THE SPINAL CORD

In this category, we have only one case. The unusual anatomic alteration found at postmortem examination explains the failure to identify the lesion during the life of the patient, and justifies the use of iodolography as a diagnostic aid.

TABLE 5.—*Observations in Cases of Diffuse Degenerative Disease of the Cerebrospinal Axis*

	Manometric Readings	Iodolography	Outstanding Neurologic Observations	Comment
Case 46 M. L.	Initial pressure 140 mm., rapid rise on straining, coughing and jugular compression	Negative	Weakness of all extremities; irregular pupils; ptosis of left eyelid, nystagmus in horizontal and vertical axis; hyperactive knee jerks and achilles reflexes; bilateral ankle clonus, bilateral Babinski sign; belt of hypalgesia, diminution of vibratory sense below that; marked scoliosis and lordosis; foot deformity	Iodized oil injected by Forestier; though a degenerative lesion was suspected, compression of the cord could not be excluded
Case 47 A. B.	None obtained	Negative	Atrophy and fibrillary twitching in right forearm and hand; contraction of right pectoral muscles; absent deep reflexes in right arm; absent abdominal reflexes; unequal knee jerks and ankle jerks, right greater than left; left ankle clonus; bilateral Babinski sign; sensory changes; diminution of vibration sense on right side	Considered a case of degenerative lesion of the cord

ILLUSTRATIVE CASE

CASE 52.—*History.*—M. B., a man, aged 50, had been well, except for an attack of influenza during the epidemic of 1918, up to May, 1923. Then, while in bed, he suddenly experienced a sensation of coldness and pins and needles in his toes. This was soon followed by gradual loss of power in the right leg. Shortly after, he developed obstinate constipation and, somewhat later, fecal incontinence. The condition remained unchanged for about two years, when, following appendectomy, he lost control of the bladder and developed recurring cramplike attacks of pain in the right leg. The numbness in that leg became marked, so that he would frequently burn himself because of failure to recognize the higher degree of heat. Three and a half years after the onset of the symptoms, he entered the Mt. Sinai Hospital.

Examination.—Weakness in both legs; right foot drop; deep reflexes in the lower extremities elicited with difficulty by reinforcement; absent lower abdominal reflexes; loss of vibratory sense below the anterior superior spines, and loss of postural sense in the toes were found.

TABLE 6.—*Observations in Cases of Transverse Myelitis*

	Neurologic Observations	Manometric Readings	Iodolography	Comments
Case 48 A. M. Man Aged 39	Paraparesis, left greater than right; knee and ankle jerks unequal, left greater than right; diminished upper abdominal reflexes; bilateral Babinski sign; hypalgesia below twelfth dorsal; diminution of vibratory sense below tenth dorsal; cerebrospinal fluid slightly yellow and contained four cells and an increase in globulin; the Wassermann tests of blood and cerebrospinal fluid were negative	Initial pressure..... 150 mm. Coughing pressure..... 100 mm. Right jugular compression 240 mm. Both jugular compressions 280 mm. Rise and fall rapid; no block	No block.....	Antisyphilitic treatment given without benefit; typhoid vaccine then given intravenously and patient began to improve and finally made a good recovery; of interest is the parallelism between the manometric readings and the iodolographic manifestations
Case 49 W. S. Man Aged 31	Unequal, irregular, sluggish to light, pupils; left central facial; weakness of lower extremities, right greater than left; slight hyperreflexia in upper and lower extremities; suspicious left Babinski sign; markedly diminished abdominal reflexes on right side, a belt of hyperesthesia about the neck, marked hypesthesia below first dorsal of right half of body; percussion tenderness over upper cervical vertebrae; Wassermann test of cerebrospinal fluid, negative	Initial pressure..... 80 mm. Coughing pressure..... 124 mm. (down in 10 seconds) Straining pressure..... 110 mm. Jugular compression..... 180 mm. (down in 16 seconds) Partial block	Bulk of oil passed down to fifth lumbar vertebra; a few globules scattered in the cervical and dorsal regions as far as the seventh and eighth dorsal vertebrae	Neoplasm of spinal cord ruled out and patient discharged as having syphilitic meningomyelitis and referred to the outpatient department for further antisyphilitic treatment
Case 50 M. G. Man Aged 50	Unequal pupils, left greater than right; questionable Horner's syndrome on the right side; deviation of the jaw to the right; slight weakness of the left side of face; atrophy of the muscle of the left shoulder girdle; a zone of hyperalgesia in third cervical to fourth dorsal; diminished upper deep reflexes on the left; active knee jerks, right greater than left; active abdominal reflexes; loss of sensation of cold below sixth dorsal; cerebrospinal fluid contained forty-four cells and revealed 4+ Wassermann reaction	Initial pressure..... 160 mm. Coughing pressure..... 220 mm. Jugular compression..... 500 mm. Rise and fall prompt; no block	A few globules arrested at seventh dorsal vertebra; no block	Patient given antisyphilitic treatment and showed progressive improvement
Case 51 J. R. Man Aged 47	Irregular pupils react well to light and in accommodation); absent lower abdominal and left cremasteric reflexes; hyperactive knee and ankle jerks, right greater than left; bilateral Babinski sign; slight ankle clonus; belt of hyperalgesia, seventh to eighth dorsal; hypalgesia in left sacral segment; the cerebrospinal fluid contained twenty cells and a slight increase in globulin; Wassermann tests of blood and spinal fluid negative	Initial pressure..... 100 mm. Coughing pressure..... 130 mm. Jugular compression..... 360 mm. Rise and fall slow, indicating partial block	No block.....	In spite of the negative iodolographic picture exploratory laminectomy decided on, but patient began to recover function and left the hospital much improved before operation was attempted

Manometric Readings.—Examination showed no subarachnoid block. The readings were: initial pressure, 160 mm.; on coughing, 190 mm.; on straining, 200 mm.; on jugular compression, 220 mm. The fluid was cloudy, contained 6 cells per cubic millimeter and gave negative serologic tests. The Wassermann test of the blood was negative.

Iodolography.—Injection of oil disclosed no block.

Course.—The clinical course was progressive. It was marked by loss of the right knee jerk, the appearance of a bilateral Babinski sign and hyperactivity of the ankle jerks. A laminectomy was then performed (in spite of the negative

Fig. 36 (case 37, table 3).—Iodologram.

iodolographic observations) for an extramedullary neoplasm, affecting mainly the roots of the cauda equina. Instead, a mass of varicose (dilated) spinal veins was found. Following the operation, the patient slowly regained some power in the legs, so that at the time of discharge on Jan. 20, 1927, he was able to get about though there still was unquestionable weakness in the lower extremities. The deep reflexes in the right leg were diminished; the lower abdominal reflexes, absent; a bilateral Babinski sign was present, and the sensory manifestations were unchanged. The patient was admitted to another hospital where another iodolograph was made, and again no block was found. He declined progressively, developed a decubital ulcer with total incontinence of urine, became septic and died in November, 1927.

Comment.—In the light of the study of Doshay and one of us (Globus),[7] it may be said that the mechanism by which dilated spinal veins precipitate signs and symptoms of tumor of the spinal cord is not that of compression but mainly that of invasion of the spinal cord. This explains the negative iodolographic observations.

GROUP XIII: SPINA BIFIDA OCCULTA

The character of the iodologram is pathognomonic of this deformity and is a good means for the identification of the lesion when other diagnostic methods fail.

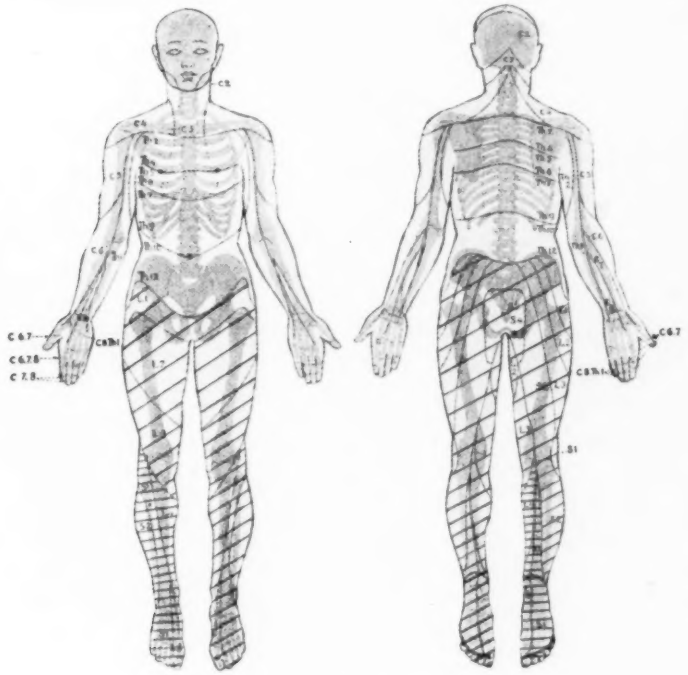

Fig. 37 (case 53).—Sensory chart.

ILLUSTRATIVE CASE

CASE 53.—*History.*—J. R., a man, aged 35, sustained an injury to his back five years previously in a fall from a moving train. There were no apparent immediate sequelae. Two and a half years later, he developed numbness in the little toe of the right foot. Within another year, a second toe of the same foot became involved. With this there developed tightness in the right knee. This was followed by gradual loss of power in the legs, and impaired control of the bowel and bladder. Following a lumbar puncture, paresis in the legs increased and control of the bladder was completely lost.

7. Globus, J. H., and Doshay, L. J.: Venous Dilatations and other Anomalies of Spinal Cord Vessels, Surg. Gynec. Obst. **48**:354 (March) 1929.

Examination.—There were: flaccid paresis of the legs, more marked on the right side; right footdrop; a zone of slight hyperalgesia at the tenth dorsal dermatome; diminution of all forms of sensation below this level (fig. 37); absent knee and ankle jerks; diminished abdominal reflexes; bilateral Babinski sign, and atrophy of lower extremities.

Manometric Readings.—An examination made at the Neurologic Institute was reported as indicating a definite block. The cerebrospinal fluid was studied there and found normal in all phases. A diagnosis of an extramedullary neoplasm of the spinal cord in the region of the tenth dorsal vertebra was made.

Iodolography.—Iodized oil was injected by cisternal puncture. It reached the level of the middle of the sacrum, at a site 2 inches (5 cm.) lower than it is usually seen (fig. 38 *A*). On the following day the larger globules of iodized oil had collected into a single large mass (fig. 38 *B*). Because of lack of experience at

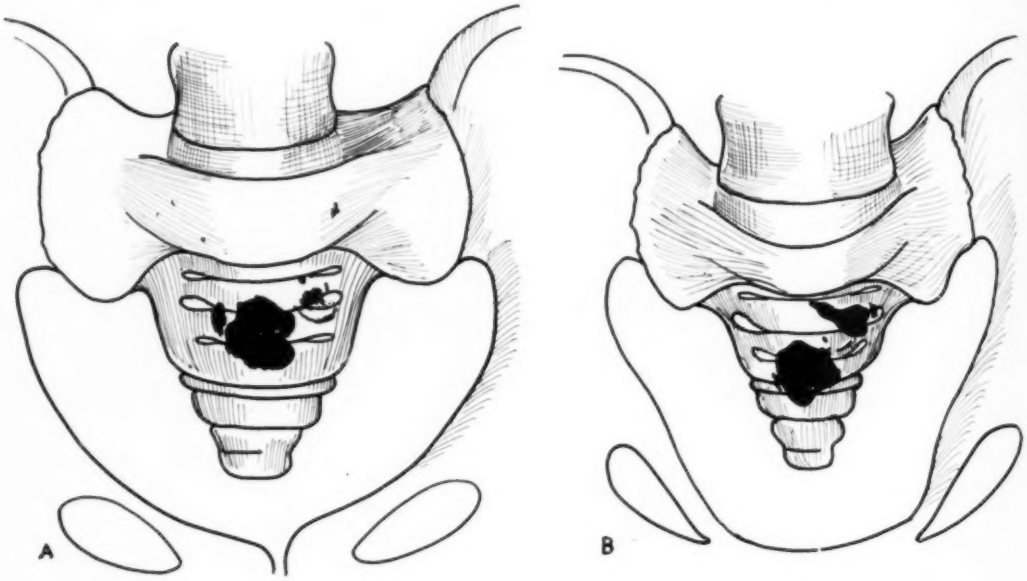

Fig. 38 (case 53).—Iodogram (tracing); *A* half hour after injection of the iodized oil; *B*, twenty-four hours after the injection of the iodized oil.

that time, no correct interpretation could be given, but an exploratory laminectomy was decided on.

Laminectomy.—The dura was normal. In the regions exposed there was a large spinal canal. The cord and the cauda equina lay at a distance of ¾ inch (1.8 cm.) from the posterior surface of the dura. The cord itself was normal. Clear cerebrospinal fluid escaped from above and below.

The postoperative diagnosis was congenital enlargement of the spinal canal. The patient passed through an uneventful convalescence and had a moderate return of function.

Comment.—The iodogram in this instance is unusual. The laminectomy made it possible for us to identify the pathologic condition

underlying it. It can be said with certainty that an iodologram of this kind always suggests a defect in the spinal canal.

GROUP XIV: NONNEUROLOGIC CASES

It is not at all unusual to make errors in diagnosis when a patient is either too cooperative or fails to cooperate. An organic lesion may in such instances be postulated. The use of iodized oil may be the deciding factor in such cases.

ILLUSTRATIVE CASE

CASE 54.—*History.*—M. S., a man, aged 72, two months before admission to the hospital began to experience constant pain in the legs, a continuous sensation of burning in the right leg and occasionally a similar sensation in the left leg. Several weeks later, he began to lose power in the right leg and was unable to walk or stand.

Examination.—Paresis of the right leg; diminished right knee jerk; absent right lower abdominal reflex; a Babinski sign on the left side; atrophy of the right lower extremity, hypalgesia and diminution of vibratory sense in the right lower extremity were found.

Manometric Readings.—Examination revealed a partial subarachnoid block. The readings were: initial pressure, 120 mm.; on coughing, 160 mm.; on straining, 170 mm.; no rise on bilateral jugular compression. In view of the manometric readings, an extramedullary lesion was suspected.

Iodolography.—The injection disclosed no block. The patient was discharged, to be readmitted several months later with diabetic gangrene of the left foot. The left leg was amputated above the knee, and he was relieved of pain.

Comment.—The negative iodologram spared this man an exploratory laminectomy.

SUMMARY

In summing up our observations on the advantages and disadvantages of intraspinal iodolography, as demonstrated in the study here reported, it is possible to answer the questions we asked ourselves at the beginning of this investigation:

1. Does the pia-arachnoid tolerate the iodized oil? Are there any untoward direct or latent meningeal reactions caused by the introduction of the foreign substance, and are there any unjustified hazards?

In all the cases, with one exception, there has been no clinical evidence, objective or subjective, of an irritation of the meninges. The one exception was in case 5, in which there were transient symptoms of general disturbance of a vasomotor nature, and also indications of local irritation as evidenced by pain in segments approximating the level of the tumor.

Twenty-five patients who have had iodized oil in their spinal canals for more than two years have been examined both neurologically and roentgenologically. Though the iodized oil showed little diminution in bulk, it remained freely movable within the subarachnoid space, and no evidence of any adhesive process appeared. Some of these patients

were inverted on a specially constructed table, and the iodized oil was seen under the fluoroscope, moving without any obstruction toward the dorsal vertebrae. A neurologic examination revealed no signs of involvement of the roots of the cauda equina or of the sacral and lumbar segments of the cord. Moreover, in one instance, case 13, a necropsy was performed three and one-half months after the iodolography; there was no evidence of any inflammatory process of the meninges at the site at which the iodized oil had been arrested. Although only sixty-two cases are included in this report, we have used iodized oil in ninety cases; in none of them have there been any untoward results or any complications.

2. What advantages are offered by this method that cannot be obtained from other available diagnostic means?

The most recent addition to diagnostic tests is the manometric examination of pressure of the spinal fluid. This method is exceedingly valuable and in most instances is a reliable means of establishing subarachnoid obstruction by an intraspinal process, which either partially or completely occludes that space. It fails, however, to demonstrate the character of the lesion, since obstruction to the free flow of spinal fluid within the subarachnoid space around the spinal cord may be occasioned by either a neoplastic lesion, an inflammatory lesion of the nature of arachnoiditis or pachymeningitis, or a deformity in the spinal canal. It throws no light on the seat or level of the obstructive lesion when the lesion occurs below the usual point of puncture. On the contrary, iodized oil serves both purposes. In the great majority of instances, it establishes the existence as well as the location of a blocking lesion, and to a certain extent it gives a clue as to the nature of the lesion.

A careful sensory examination is still the essential diagnostic approach to the localization of lesions of the spinal cord. It is, however, well known that this method is subject to uncertainties because of the subjective reactions of the patient as well as the personal equation on the part of the examiner. It is the experience of every neurologist that the most careful sensory examination, with the most careful interpretation of the data so obtained, does not always yield the information which enables one to name definitely the vertebral level of the lesion. At laminectomy it frequently happens that the tumor is not found at the level indicated by careful sensory studies, and recourse is had to a probe which generally reveals to the operating surgeon the site of the obstruction a short distance above or below the supposed level. Unfortunately, not uncommonly the probe may pass such an obstruction, and unless the neurologist is convinced of his diagnosis and insists on the exposure of adjacent levels, the tumor may be entirely missed. In such instances, laminectomy of one or more vertebrae becomes necessary to visualize the lesion. Though the removal of several laminae does not cause any

great injury to the patient, it nevertheless becomes an unnecessary procedure when there is a method available to obviate it.

This method is especially valuable in tumors of the middorsal region where the level at first appears to be in the lower segments of the dorsal cord and then shifts upward, over a period of time, gradually to higher levels and causes the neurologist considerable anxiety in determining the final level.

The location of the tumor may be below the second lumbar vertebra, the usual level at which lumbar puncture is performed, and the manometric test then fails to give any evidence of its existence. Iodolography is then of great service and can, if desired, be performed by injection through the lumbar puncture needle.

In our experience as well as in that of others, iodolography has also helped in a great measure to identify the type of the compressing lesion. In secondary metastatic tumors, when two or more foci are present, iodized oil is arrested at the corresponding levels. In this way, the presence of independent multiple lesions is detected. Of course it might be said that in such cases the suspicion of malignant disease would lead to an examination of the chest, where a primary neoplasm may be existing without symptoms, and would thereby obviate the necessity of an injection of iodized oil. On the other hand, unless the practice of excluding a primary lesion in every case of obstruction in the subarachnoid space is adhered to, mistakes will be made in the diagnosis of a malignant condition unless iodized oil is used. It is obvious that the ability to establish the malignancy of the process obviates the need of an unnecessary laminectomy.

Iodolography, by producing a fairly characteristic intraspinal shadow, has helped us in identifying inflammatory lesions in the meninges on occasions when the clinical picture, sensory examinations and manometric estimation made the diagnosis of tumor of the spinal cord almost a certainty. If it were not for the experience we have had with the iodolographic observations, and if we were not fortified in our views by the clinical course and events which followed the injection of iodized oil in such instances, we would find even at the present day great difficulty in diagnosing conditions now identified as arachnoiditis, nor would we make the diagnosis of arachnoiditis unless we had confirmation by means of iodolography. The four cases which are included in the group of cases of arachnoiditis do not exhaust the entire number of similar instances which have come under observation. Since collecting the data for this paper, we have had two more instances in which a similar problem was presented and solved by the use of iodized oil. Both patients are recovering without laminectomy.

Multiple sclerosis, particularly affecting the spinal cord, not uncommonly gives rise to sensory disturbances not unlike those associated with

a level lesion. Even when the neurologist is morally certain that he is dealing with this type of disease of the spinal cord, all doubt can be removed by iodolography. In this disease iodized oil is occasionally arrested within the limits of the level established by sensory examination. In such instances, however, the iodized oil assumes the character seen in cases of arachnoiditis, i.e., globules which are variable in size and irregular in distribution; this is very likely due to a meningeal process of the reactive type frequently found in the course of multiple sclerosis. We have had four such cases in which manometric estimation of the spinal fluid pressure showed partial block and also showed collections of iodized oil of the character mentioned.

When we approach the problem of distinguishing intramedullary from extramedullary tumors, iodized oil offers less definite information. Though in every instance the presence of an extramedullary tumor is established, the oil does not produce a shadow which may be regarded as characteristic of an intramedullary tumor. In cases of intramedullary tumor, iodolography occasionally gives the features of complete block.

3. When should iodolography be used? When is this method unnecessary or undesirable?

In every case in which a tumor of the spinal cord is strongly suspected, even when the level is made out with reasonable certainty, the injection of iodized oil is strongly advised in order to give the surgeon a more secure guide in seeking the lesion. It is also an additional safeguard as it helps to exclude any possible errors in diagnosis on the part of the skilled neurologist. It is, however, not needed in instances of metastatic processes which are identified by the presence of a primary growth or by the presence of a characteristic destructive process in the spinal column associated with the history of previous malignant disease or tuberculous caries.

CONCLUSIONS

1. Iodized poppy seed oil 40 per cent is the type of iodized oil that we have used in this investigation. It proved to be nonirritant and well tolerated by the pia-arachnoid membranes of the spinal cord. Patients who received such injections were observed over a period of two and a half years. They revealed no manifestations of root irritation. Though the absorption of the iodized oil in the subarachnoid space is exceedingly slow, it nevertheless remained unencapsulated and freely movable in that space, provoking no recognizable signs of focal or diffuse involvement of the spinal cord or its membranes.

2. With rare exceptions, iodized oil maps out more definitely than any other diagnostic method the level of compression of the spinal cord, particularly when such compression is caused by an extramedullary tumor. Occasionally, when the compressing lesion is of the more rigid type (osteoma, chondroma) and is situated on the anterior aspect of the

cord, it may pass by the partial obstruction and reveal no arrest. Also, in rare instances, the iodized oil may be arrested by one or two segments above the tumor mass because of existing arachnoid adhesions above the upper limits of the tumor.

3. Iodolography aids in the recognition of an intramedullary lesion by the exclusion of an extramedullary tumor, and helps in the identification of other obstructive lesions such as pachymeningitis and arachnoiditis.

4. Negative iodolograms, which exclude the existence of a compressing lesion, aid in the identification of degenerative or inflammatory lesions of the spinal cord, which because of misleading symptoms simulate tumors of the spinal cord.

5. Anomalies, such as spina bifida occulta or other abnormalities of the spinal canal, may often be recognized by atypical distribution of the iodized oil in the subarachnoid space.

6. Iodolography, however, does not minimize or take the place of thorough studies by established neurologic methods and should be regarded mainly as an additional valuable diagnostic test when other methods are not sufficiently convincing.

We are indebted to Dr. H. Lampert for the preparation of these pictures.

ABSTRACT OF DISCUSSION

Dr. Byron Stookey, New York: Iodized oil has a valuable position in the diagnosis of diseases of the spinal cord, not only neoplasms but diseases themselves, and one should make an effort to determine just where and when this method should be employed. This procedure should not be used in every case. In how many of the cases reported was the level in doubt? In how many was diagnosis impossible without the aid of iodized oil?

I am aware that the cases of Dr. Strauss and Dr. Globus have as yet shown no evidence of encapsulation; they have studied this by reversing the patient, and they have undoubtedly verified their results. I do not know that iodized oil will eventually show encapsulation in their cases, but even if it does I believe that the introduction of a foreign body should not be done as a routine procedure. I believe that it has definite indications, and these, I hold, are when the combined neurologic staff is unable to arrive at a united opinion as to the evidence of the level. The use of iodized oil is particularly indicated in tumors of the cauda equina, because the neurologic signs are identical for a number of levels. Furthermore, it aids in the differential diagnosis between tumors of the cauda equina and radiculitis.

Dr. Strauss and Dr. Globus have said that there are no signs of irritation. I have operated in two cases in which iodized oil had been used; in one, several weeks after the injection, I found a marked irritation of the cord and meninges. I am not prepared to say that this was due to the iodized oil. Nevertheless, it was associated with it, and it was not, so far as the clinical signs showed, an inflammatory condition.

Furthermore, I reported two cases last year before this association, in which iodized oil gave a negative report. The manometric study was questionable as to

whether or not there was a block. One of the tumors was an extradural growth, a ventrally placed chondroma. It was so small that it caused no real obstruction and the iodized oil went by.

Dr. W. G. Spiller, Philadelphia: We are fortunate in having in the authors of this paper men of much diagnostic ability, and they have shown by the report of their cases that it is sometimes difficult to decide that the manifestations in a given case are unreliable for localization. Occasionally, the upper level of a tumor of the spinal cord cannot be distinguished clinically; however, in the second case reported in this paper it is stated that the sensory level was distinct and was at the sixth thoracic level, but the tumor was shown by iodized oil to be at the tenth thoracic segment. There is hardly a more reliable diagnostic measure than the upper level of sensory loss. This case is not unique in the literature. Dr. Strauss and Dr. Globus have used iodized oil in all the cases reported in this paper. If they had only used iodized oil in the cases in which the diagnosis seemed doubtful, they probably would have made a wrong clinical diagnosis in the case to which reference has been made.

There may be considerable difficulty even with the use of iodized oil in the diagnosis between a tumor of the cauda equina and radiculitis of the cauda equina. Only recently, I was in consultation in such a case. Operation was performed, and it was found that severe radiculitis had given the symptoms of a tumor of the cauda equina. The roots were greatly swollen, and it is doubtful whether any iodized oil could have got past them.

Dr. J. B. Ayer, Boston: I am surprised that Dr. Strauss speaks of "dispelling the gloom" in connection with the usage of iodized oil, for I had assumed that this diagnostic agent had been generally accepted. The only point in question appears to me to be whether one shall use iodized oil as a routine or only occasionally. I am against its too free use because, in spite of what has been said concerning its innocence, it is an irritant. If one examines the fluid shortly after the injection of iodized oil it is opaque and contains many hundreds of cells. Likewise, the oil stays in the system a long time. I understand that in France three years have seen its disappearance, at least as far as roentgen studies can demonstrate this point. I should therefore take a similar stand to that of Dr. Stookey, namely, that if a clinical level is demonstrable and subarachnoid block can be demonstrated, iodized oil is unnecessary.

I shall have to admit immediately that there are exceptions to this rule in such cases as Dr. Spiller has mentioned and as a case of my own demonstrated. The case to which I refer showed an excellent clinical level in the midthoracic region and a block. The iodized oil, which was fortunately used in this case, stopped at a cervical level. Operation on the cervical cord demonstrated a tumor, which was removed. Subsequently the block was shown to persist, and a second tumor was removed from the level at which the clinical examination had indicated the tumor. In this case both the clinical and the iodized oil studies were correct, although not agreeing.

The chief difficulties with iodolographic interpretation have not been in cervical, thoracic and lumbar cord tumors, but with tumors in the region of the cauda equina. It is in this group that I believe iodized oil will have an increasing usefulness, for the clinical study of tumors of the cauda equina is far from being satisfactory. The injection of iodized oil has helped not in direct indication of a tumor, but in determining the size and shape of the sacral canal; this is determined by means of the fluoroscope with change of positions.

One more point should, I think, have been brought out in Dr. Globus' paper and that is the use of the fluoroscope in contradistinction to the roentgenogram. In one case, we were able to show a block by combined cisternal-lumbar puncture. By lumbar puncture alone we should have missed it. Iodized oil in this case went by the block. This was shown by the roentgenogram. If we had used fluoroscopy, we should undoubtedly have seen the iodized oil passing by the tumor which was, in fact, found.

In conclusion, I should emphasize the great value of iodized oil in localization; I should also emphasize the importance of accurate interpretation, and I should advise against its routine use. More frequent use of the fluoroscope in connection with iodized oil is advisable, although a special tilting table is almost a necessity in such use.

Dr. I. Oljenick, Amsterdam: Some of my experiences are similar to those about which Dr. Ayer spoke. When iodized oil was used in Amsterdam for the first time, neurologists were afraid of the suboccipital puncture. A table like the one Dr. Ayer mentioned, which could be reversed, was used. When iodized oil was introduced by the lumbar route, the under surface of the tumor could be determined in the head-down position. In the next case the iodized oil gradually passed by a relative stop, and when the table was reversed, the iodized oil was seen to flow downward until it came to a relative stop at the upper surface of the tumor, as seen under the fluoroscope and in the roentgenogram. However, the suboccipital injection is now done as a routine.

I want to emphasize the fact that in cases in which there is any doubt about localization of the tumor, it is not sufficient to use iodized oil only from above. To avoid diagnostic mistakes in cases of double tumor of the spinal cord, iodized oil should be introduced from above and from below in a case of a complete block. If the tumor or eventually the tumors are located in the dorsal region, the upper and lower levels may be determined by raising the pelvis and shoulders at the same time. The space between the two iodized oil shadows, being shown on the roentgenograms, gives the exact localization and the exact dimension of the tumor.

The second point is this: for the clinical diagnosis of the upper level one has to rely on the subjective feelings of the patient. Often, iodized oil is a great help in making this upper level much more definite. It is possible that irritation of a root or pressure on a root by the tumor may not act as an adequate stimulus to produce changes in sensation. On the other hand, iodized oil often increases the irritative pressure effect of the tumor so much that together they act as an adequate stimulus indicating which is the highest root involved.

Dr. C. A. Elsberg, New York: It has been my fortune to operate on a number of the patients whose roentgenograms were presented by Dr. Globus and Dr. Strauss, and it has been my special fortune to have been asked to see these patients and to examine and operate on them after the injection of iodized oil. I always made it a rule, before seeing the roentgenograms made after the injection of iodized oil, to examine the patient carefully myself, to determine the level and to note down what laminae should be removed in the operation for the tumor. Being averse to using this method in any instances except those in which all other diagnostic methods and procedures have failed, I felt strongly that in a number of these patients iodized oil should not have been used. I soon realized, however, that the reason Dr. Globus and Dr. Strauss were using iodized oil was not that they thought it was necessary in every instance but that they were attempting to determine the advantages and the disadvantages of this new, or relatively new, method.

All are agreed, as most of those who have spoken have said, that when there is difficulty in distinguishing between a neuritis of the cauda equina and a tumor between the roots of the cauda equina, or in determining whether a tumor is located over the lower portion of the conus or somewhere between the roots of the cauda equina, when, as happens not so rarely, the level is indefinite, although clinical examination and manometric tests have determined that there is a tumor, in all such cases iodized oil may be useful.

I thoroughly believe that iodized oil is an irritant. I have seen, in a number of instances, fresh adhesions and marked congestion of the meninges and roots which are not ordinarily observed when the spinal cord is exposed during the course of a laminectomy, and have always explained this as a result of the irritating qualities of this foreign substance.

Nor do I think that one can say with any certainty—unless a patient is reoperated on or dies and is subjected to a postmortem examination—whether, and if so, when, the iodized oil disappears. The x-rays are not reliable evidence because it may well be that the iodine has disappeared and that the cottonseed oil, or whatever the oil may be that has been used, is still there as a foreign body.

One aspect of this subject is of surgical importance. The level of the tumor with reference to the vertebrae can be determined by means of iodized oil more exactly than by other neurologic or laboratory methods. It is true that the removal of one or possibly two additional spines and laminae does no harm, but from the ideal standpoint no more bone should be removed than is absolutely necessary. In operations for tumors of the cord it must have happened to everyone that one or two additional laminae had to be removed, because the growth was located at a somewhat higher (or lower) level; such an occurrence would certainly be rare if injections of iodized oil were made in every patient with a tumor of the spinal cord. Whether this advantage would be great enough to outweigh the disadvantages from the introduction of a foreign substance into the subarachnoid space is an open question. I, myself, would prefer to take the chance of having to remove one or two laminae more rather than to inject iodized oil, but I have an open mind on the question. By means of iodized oil, the proper laminae that have to be removed can be so exactly determined that this is an additional great advantage to which not sufficient reference has been made.

However, I do believe, as has been said by everyone—and I believe this is also the opinion of the readers of the paper—that iodized oil should be used only in those instances in which all other methods have failed to determine a definite level for the surgical procedure.

DR. STRAUSS: As has been said, we preceded every injection of iodized oil by the manometric determination of the spinal fluid pressure and, naturally, by careful neurologic examination. At no time did the manometric pressure fail to give a clue to the existence of the neoplasm within the spinal canal. Before injecting iodized oil, we were therefore convinced that we were dealing with some lesion causing a compression of the spinal cord. Furthermore, the neurologic signs were in most cases definite enough to establish the localization of the lesion.

At times, we have found difficulty in differential diagnosis between an extramedullary and an intramedullary lesion. In these cases we have used iodized oil and it has been of service to us, but here is an important point: iodized oil cannot be used and just looked at under a plate and a diagnosis made of obstruction or partial obstruction, unless one realizes that it requires experience in interpretation of the picture.

We have not used the lumbar route for this method, although Forestier does that now, I believe, almost exclusively, because it requires a specially constructed table which is not available at the time this work was done.

CHANGES IN THE INTERSTITIAL CELLS OF THE BRAIN WITH MORPHINE INTOXICATION*

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The improvement in the silver staining methods and the better appreciation of the finer structure of the interstitial cells of the central nervous system have afforded another approach for neurologic investigation. In the study of intoxication, for example, abnormalities of the glia cells may be of double significance. Destruction of the glia may lead secondarily to abnormal neuron function. Also, the presence of definitely degenerated glia indicates that an intoxicant is causing similar (although perhaps less apparent) damage to the neuron.

This investigation was planned with a triple purpose: (1) to test the value of the interstitial cells of the brain as indicators (through structural change) of intoxication of the central nervous system; (2) to study the course of degeneration and regeneration in the interstitial cells during intoxication and recovery, and (3) to establish a closer correlation of structure to function in intoxication.

The effect of morphine on the structure of the neuron has been repeatedly studied, but the intoxications were usually extreme. When but mildly poisoned, slight or delicate alterations in the neuron are difficult to interpret. The interstitial cells have not been as thoroughly examined, and comparison of the degeneration in glia and neuron is difficult because each requires its special fixing and staining methods.

The conspicuous toxic change in the microscopic structure of the neuron is fatty degeneration.[1] In cases of mild intoxication the process may progress no further than slight swelling of the neuron or alteration of the staining reaction. In more severe cases, fat droplets or vacuoles appear in the cell, and in cases of extreme intoxications, or

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1. Von Tschischt, W.: Virchows Arch. f. path. Anat. **100**:147, 1885. Spielmeyer, W.: Histopathologie des Nervensystems, Berlin, Julius Springer, 1922. Weimann, W.: Ztschr. f. d. g. Neurol. u. Psychiat. **90**:83, 1924; Deutsche Ztschr. f. d. ges. gerichtl. Med. **8**:205, 1926; Ztschr. f. d. ges. Neurol. u. Psychiat. **105**:704, 1926. Schutz, O.: Neurol. Centralbl. **27**:157, 1908. Creutzfeldt, H. G.: Ztschr. f. d. ges. Neurol. u. Psychiat. **101**:97, 1926.

in instances where milder intoxication has been greatly prolonged, it may be totally destroyed. The appearance of pigment granules with degeneration of the neuron has also been reported.[2]

Mankowsky[3] observed similar degeneration in animals poisoned with morphine. He emphasized the nonspecific character of the neuron changes and identified them with those caused by other intoxicants. Mott, Wodehouse and Pickworth[4] observed that hypnotics of the sulphone and barbitone groups may produce the same general microscopic alterations in the nervous system.[5] The interstitial cells did not receive much attention, and there is no way of knowing whether degeneration was more apparent in these cells than in the neuron.

Creutzfeld[6] found "fat droplets" in the oligodendroglia cells of a morphine addict killed by an overdose. His material was fixed twenty hours after death. The observations, therefore, are difficult to interpret since oligodendroglia cells begin to degenerate six hours after death.

Penfield and Cone[7] and Cone[8] demonstrated that oligodendroglia may be the only group of interstitial cells to show change in infection or intoxication. The astrocytes and microglia in the same brains may be quite normal in appearance. But with extreme, acute swelling of the oligodendroglia, the astrocytes may also show evidence of acute change. Oligodendroglia degeneration is often far advanced, however, before microglia cells begin to assume an ameboid form.[9] To quote:[8] "It

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2. Creutzfeldt (footnote 1, seventh reference). Nissl, F.: Allg. Ztschr. f. Psychiat. **54**:1, 29, 1897-1898.

3. Mankowsky: Russk. Arch. f. Path. **66**:67, 1898.

4. Mott, F. W.; Wodehouse, D. L., and Pickworth, F. A.: Brit. J. Exper. Path. **7**:325, 1926.

5. One of the plates illustrating mucoid substances in the pons of a sulphonal-fed monkey suggests that there was swelling of the oligodendroglia. Lotmar's (Nissl- Alzheimer's Arbeiten. **6**:245, 1918) description and photographs of the glia cells after dysentery intoxication also indicate that in addition to neuron disease and microglial ameboid forms, he produced acute swelling of the oligodendroglia.

6. Creutzfeld (footnote 1, seventh reference).

7. Penfield, W., and Cone, W.: J. f. Psychol. u. Neurol. **34**:204, 1926.

8. Cone, W.: Acute Pathologic Changes in Neuroglia and Microglia, Arch. Neurol. & Psychiat. **20**:34 (July) 1928.

9. Penfield and Cone (footnote 7) emphasize that the terms "amoeboid glia cell" or "gitterzellen" are properly used only in reference to the ameboid form of microglia since this is the only form of wandering interstitial phagocyte in the central nervous system. The ameboid glia cell has often been confused with the acutely swollen oligodendroglia cell which differs from the ameboid type in that it is immobile and only incidentally phagocytic.

Bailey and Schaltenbrand (Bailey, P., and Schaltenbrand, G.: Deutsche Ztschr. f. Nervenh. **97**:231, 1927) have demonstrated from the brain of a patient with encephalitis periaxialis diffusa that Grynfelt's mucocyte degeneration and Penfield's acute swelling of oligodendroglia represent different stages of the same process.

(microglia) reacts secondarily, changing not with, but after, degenerative lesions in nerve cells and neuroglia."

Thus oligodendroglia appear to be the cells "most sensitive" to the action of intoxicants. This demonstration that oligodendroglia are very "sensitive" and may degenerate after the use of morphine and other intoxicants suggested that a study of these cells at various stages of experimental intoxication might reveal the very beginnings of degeneration of the nervous system.

Dogs were intoxicated with morphine and the oligodendroglia cells were especially studied. The astrocytes, microglia and neurons were also examined, and the tissue was stained for mucin.

METHOD

Twenty dogs weighing from 10 to 15 Kg. were given subcutaneous injections of morphine sulphate in varying quantities continued over periods of from three hours to eighteen days. The animals were grouped, according to the intensity and duration of the drug administration, into five classes. In the groups in which the drug was repeatedly administered, the duration of lethargy following each injection was taken as an index of intoxication. Since the animals' food was placed in the cage one hour after the morning injection, it was possible to determine approximately the period of lethargy by noting the time interval between the time of injection and the time at which the animal took food.

Class A consisted of two dogs. One received a total of 389 mg. per kilogram in three injections at five hour intervals, the other received a total of 232 mg. per kilogram in three injections at five hour intervals. Both were killed twenty-four hours after the first injection.

Class B consisted of two dogs. Each received 3.1 mg. of morphine per kilogram. They were killed three hours after injection.

Class C consisted of six dogs. Each received a total of 34.2 mg. of morphine per kilogram in five injections at four hour intervals. Four were killed twenty-four hours after the first injection, and the remaining two were allowed to recover for nine days and then were killed.

Class D consisted of four dogs. Each received 2.4 mg. of morphine per kilogram per day in two injections, twelve hours apart, for eleven days. The total injection thus amounted to 26.4 mg. of morphine per kilogram for each animal.

Class E consisted of five dogs. Each was given two injections a day, twelve hours apart, for eighteen days. The daily total injection was slowly increased over this period from 2.4 to 10.8 mg. per kilogram, giving a total for the whole period of 108.2 mg. per kilogram.

A control dog was run with groups D and E. It was, of course, given no drug and was fed on the same diet and lived under the same conditions. Controls for all classes were made from the normal material so kindly given us by Dr. Penfield.

A daily record was kept of the animals in groups D and E. The quantity of food taken, the duration of lethargy, number of stools, micturition, vomiting, general condition of health, etc., were recorded. The weight was also measured at intervals throughout the experiment.

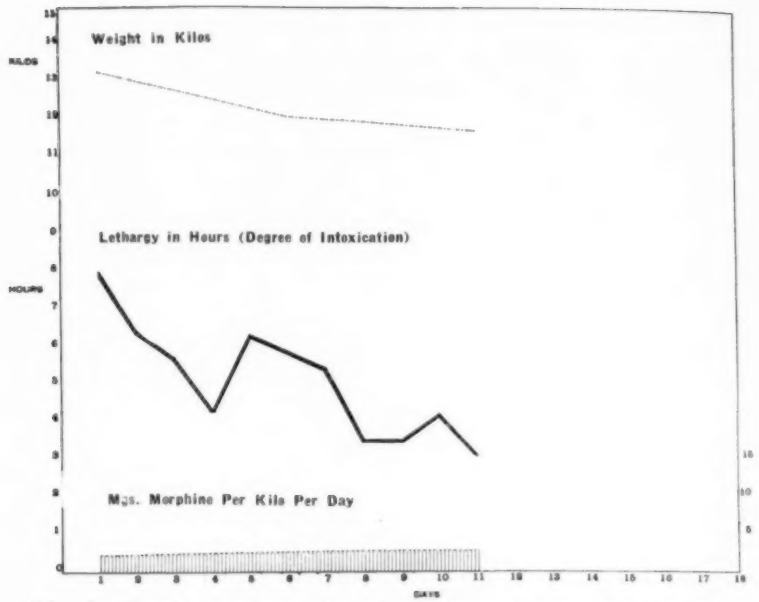

Fig. 1.—Graphic representation of the protocol for class D. The curves are constructed from the average figures computed from the daily protocols of each animal. The abscissa, as indicated, represents days (duration of intoxication). The ordinate, for the weight curve, represents kilograms; for the lethargy curve, represents hours; and for the morphine curve, the ordinate is read as milligrams per kilogram of body weight per day.

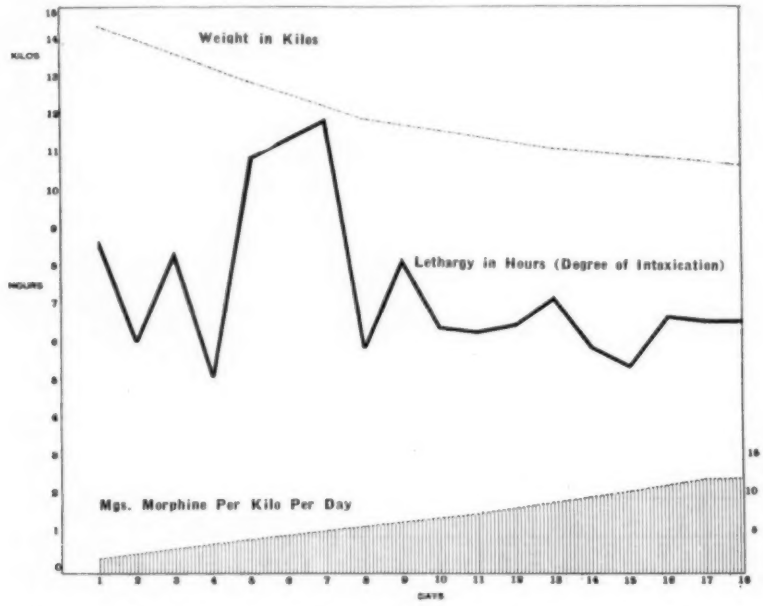

Fig. 2.—Graphic representation of the protocol for class E. Data obtained as in figure 1.

The diet of all animals was practically constant. It consisted of 16 ounces (497.6 Gm.) of horse meat, with occasional additions of 2 ounces (62.2 Gm.) of dog biscuit. Unmeasured amounts of water were given.

At the end of the experimental period, all but one animal were killed with ether as rapidly as possible.[10] Into the brains in situ, through the carotid artery, was injected a solution of formaldehyde-ammonium bromide; the brains were then removed immediately. One dog in class A, unconscious as a result of morphine intoxication, was killed directly by injection of the formaldehyde-ammonium bromide.

Cubes of cerebral cortex, approximately 1 cm. square, were taken from the frontoparietal region.[11] Frozen sections were so cut and mounted as to include considerable white matter. The tissue was left in formaldehyde-ammonium bromide for five days. The del Rio Hortega silver carbonate method for astrocytes was used after the brains had been in formaldehyde-ammonium bromide for one month. Formaldehyde fixed material was stained with cresyl violet. Grynfelt's stain for mucin was tried in all animals.

The degree of swelling of the oligodendroglia cells observed in the various groups is indicated in the following description by the multiple plus method. Thus, less than 1 plus is considered to be within the physiologic limits of normal, whereas four plus indicates striking degeneration and swelling.

OBSERVATIONS

Determination of the swelling of the oligodendroglia was at best arbitrary and relative. The classification of degrees of degeneration was based on the metamorphosis undergone by these cells in the various stages of disorganization. The following scheme was adopted for convenience of grouping.

Stage 1 (+).—Oligodendroglia showing no, or a barely perceptible, clear cytoplasmic rim, with swelling of the intact cytoplasmic processes, especially at the "knees." The nucleus has a jet black margin with a pearly gray, homogeneous center. At the greatest diameter of the cell, the maximum distance from the cell wall to the edge of the nucleus, as compared to the diameter of the nucleus, is as 1 : 5.

Stage 2 (++).—Oligodendroglia show a slight but definitely increased rim of cytoplasm with a few filamentous connections (girders) between the nucleus and the cell wall. The nuclei are slightly more heavily stained than those of class 1. The cytoplasmic processes are swollen, have bulbous knees or are absent. At the greatest diameter of the cell, the maximum distance of the cell wall from the edge of the nucleus, as compared to the diameter of the nucleus, is as 2 : 5.

10. It has been demonstrated by Penfield that ether anesthesia for as long as six hours does not cause oligodendroglia swelling.

11. It is conceivable that the neurons of the hindbrain, midbrain or thalamus, i.e., the cells responsible for many of the signs and symptoms of morphine poisoning, might show more obvious abnormalities than those of the cortex. It was considered more accurate, however, to compare interstitial cells and neurons from the same site.

Stage 3 (+++).—Oligodendroglia show a definite and still greater increase of cytoplasm, with "girders" connecting the nucleus and the edge of the swollen cell. At the greatest diameter of the cell, the maximum distance of the cell wall from the edge of the nucleus, as compared to the diameter of the nucleus, is as 3:5. The nucleus is usually dark. The protoplasmic expansions have almost completely disappeared.

Stage 4 (++++).—Oligodendroglia showing a large increase in cytoplasm about a darkly staining nucleus. There are no cytoplasmic expansions. Most of the "girders" have disappeared. At the greatest diameter of the cell, the maximum distance between the edge of the nucleus and the cell wall as compared to the diameter of the nucleus is as 5:5.

In class A (dogs receiving an average of 2.90 mg. per kilogram and killed in twenty-four hours), the dog in which the symptoms during the administration of the drug indicated the greatest intoxication showed a stage 3 swelling and the other, a stage 2.[12]

In class B (the dogs receiving 3.1 mg. per kilogram and killed in three hours), less than stage 1 swelling was shown.

The first four dogs in class C (those receiving an average total dose of 34.2 mg. per kilogram and killed in twenty-four hours) showed stage 1 to stage 2 swelling, and the two allowed to recover showed less than stage 1 swelling.

The dogs in group D (those receiving an average of 26.4 mg. per kilogram and killed in eleven days) had a fairly constant stage 3 swelling, although there was some variation between individual animals.

The dogs in group E (those receiving an average of 108.6 mg. per kilogram and killed in seventeen days) had stage 4 swelling throughout.

The control for these groups had less than stage 1 swelling.

Dogs in groups D and E (long intoxication) showed a steady loss of weight. The loss in weight was not in itself responsible for the oligodendroglia swelling. In class E, one dog (E_2), weighed 0.3 Kg. less after eighteen days of intoxication. The oligodendroglia showed stage 4 swelling. The animals in groups D and E maintained good health throughout the experimental period.

The astrocytes in dogs of group E showed occasional swellings or beadings of the processes. In no instance was clasmatodendrosis

12. It must be emphasized that a 4 plus swelling is not the maximum possible swelling. The grouping here used applies only to the conditions of these experiments. The second dog had seven fits and was unconscious much of the time, whereas dog 1 had but one fit and was conscious or partially so until killed. Moreover, he received a smaller dose than dog 2 (table).

observed. In group D, there was less swelling of the astrocyte protoplasmic processes. The astrocytes in the remaining groups appeared to be normal.

The microglia was altered in no instance.

The nerve cells stained with cresyl violet showed varying degrees of change in structure. The difficulty of interpreting these changes makes necessary a brief description of the appearance of the nerve cells in each animal.

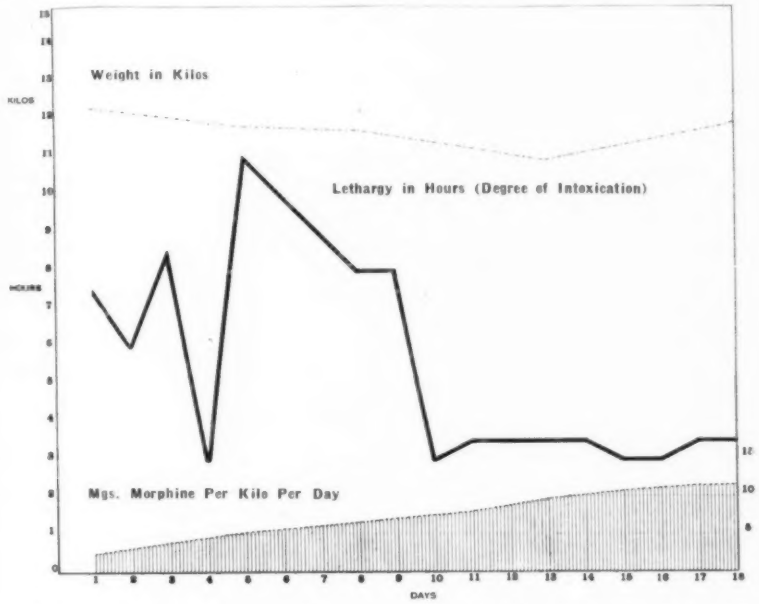

Fig. 3.—Graphic representation of the protocol for dog E. This animal had a stage 4 swelling of the oligodendroglia. The protocol differs from the average in that there is a gain of weight during the last five days of the intoxication. This observation suggests that there is no relationship, in these experiments, between loss of weight and oligodendroglial changes.

APPEARANCE OF NERVE CELLS

Class A.—1. The laminations of the cortex appeared normal. Many of the small nerve cells had a marked satellitosis. Most of the larger nerve cells in the deep layers were normal, but some were pyknotic.

2. The blood vessels were somewhat congested, and there was a more marked satellitosis than was apparent in the other dog of this class. A small nest of pericapillary cells was found in the white matter below the sixth layer of the cortex. These cells were mostly endothelials and lymphocytes.

Class B.—1. The cortical lamination appeared to be normal. There was no congestion of the vessels. There was only slight satellitosis and a few pyknotic cells. A small collection of round cells, consisting mostly of large mononuclears and lymphocytes, was seen in the white matter near a vein.

2. The vessels were more congested than in the other animal of this group. Some of the vessel walls seemed to be hypertrophied. The laminations were normal.

Class C.—1. The sections stained unevenly, and the lamination was not distinct. Several small areas in the third and fourth layers of the cortex were almost devoid of normal nerve cells. The cells were in various stages of degeneration, and the surrounding nerve cells stained rather heavily.

2. The vessels were greatly congested. Lamination was fairly clear, and nerve cells stained moderately well. There was a small focus in the fourth layer where the nerve cells were pale and few in number. The degeneration in this focus was not so great as in 1 of this series.

Degree of Oligodendroglial Swelling in Dogs Intoxicated with Morphine Sulphate

Dog	Breed	Sex*	Weight, Kg.	Total Dose, Mg. per Kg.	Duration of Intoxication	Oligodendroglia Swelling	Average Total Dose
A_1	Fox terrier.....	♀	15.9	232	24 hours	++	3 injections totaling 290.7 mg. per Kg.
A_2	Airedale.....	♂	9.5	389	24 hours	+++	
B_1	Spaniel.....	♂	9.3	3.2	3 hours	0 or ? +	1 injection of 3.1 mg. per Kg.
B_2	Yellow cur.....	♀	10	3	3 hours	0 or ? +	
C_1	Airedale.....	♂	12.7	30.7	24 hours	+	5 injections totaling 34.2 mg. per Kg.
C_2	Yellow cur.....	♀	12.7	30.7	24 hours	++	
C_3	Beagle.....	♀	11.9	32.8	24 hours	+	
C_4	Yellow cur.....	♂	10.5	37.1	24 hours	++	
C_5	Collie.....	♀	9.1	42.8	24 hours and 9 days recovery	0 or ? +	
C_6	Yellow cur.....	♂	11.4	34.2	24 hours and 9 days recovery	0 or ? +	
D_1	Beagle.....	♀	11.3	26.5	10 days	+++	22 injections totaling 26.4 mg. per Kg.
D_2	Collie.....	♂	11.5	28.7	11 days	+++	
D_3	Irish terrier....	♀	13.9	24.8	11 days	+++	
D_4	Boston terrier.	♀	13.2	25.6	11 days	+++	
E_1	Brindle cur.....	♂	10.3	118.9	16½ days	++++	36 injections totaling 108.2 mg. per Kg.
E_2	Collie.....	♀	12.1	111.1	17½ days	++++	
E_3	Airedale.....	♀	14.3	92	17 days	++++	
E_4	Collie.....	♀	13.6	105.9	16 days	++++	
E_5	Brindle cur.....	♂	10.7	114.9	14 days	++++	

* In this column, ♂ indicates male; ♀, female.

3. The blood vessels appeared to be somewhat hypertrophied. The nerve cells in general stained well, but with considerable variation. A small focus was seen in the outer part of the fourth layer similar to those already described. Two other areas in the same layer showed less marked degenerative changes.

4. The meninges were congested. The nerve cell nuclei of the fourth and fifth layers stained darkly. There was a diffuse area extending along the fourth layer where there was a sparsity of nerve cells with considerable degeneration.

5. The blood vessels appeared to be normal. The nuclei of the nerve cells were swollen, particularly in the fourth layer.

6. The vessels were normal. The nerve cells showed diffuse degeneration in the fourth layer.

Class D.—1. The blood vessels seemed normal. There were a great many large nerve cells with eccentric and darkly staining nuclei.

2. The blood vessels were normal. The nerve cells in a few areas showed mild degenerative changes. The cells in the tips of two gyri were much paler than the cells in the adjacent sulci.

3. The blood vessels were thick-walled and rather congested. There was considerable satellitosis, and a few lymphocytes were seen in the perivascular spaces.

4. The blood vessels were normal. The laminations were fairly clear. There were many dark, pyknotic nerve cells but no true areas of necrosis.

Class E.—1. The blood vessels were congested, and there was an increased number of endothelial leukocytes. The fourth layer stained less deeply than the rest of the cortex. A long diffuse focus of degeneration was found in the fourth layer, and a smaller area in the fifth layer and the lower part of the fourth.

2. Material missing.

3. The vessels were congested and had thick walls. There were several groups of swollen nerve cells found, one particularly marked in the third layer. The abnormality was not as pronounced as in 1 of this group.

4. The blood vessels were normal. The fourth layer was not as intensely stained as the others and showed many swollen nerve cells. The changes were

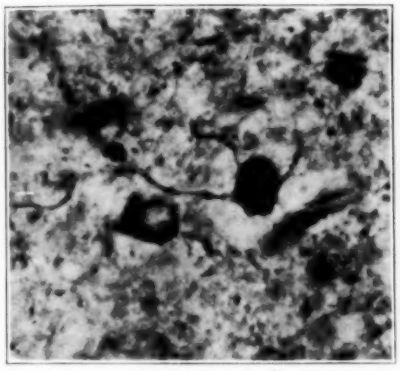

Figure 4

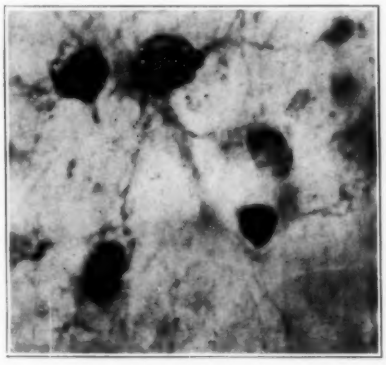

Figure 5

Fig. 4.—Normal oligodendroglia cell. The legs or protoplasmic expansions are thickened to the upper limit of normal, the "knees" slightly swollen, somewhat more than average.

Fig. 5.—Oligodendroglia from group C, swelling ++. Dog C_2 received 30.7 mg. per kilogram; it was killed after twenty-four hours.

not so confined to the fourth layer as in previous cases, but they were diffused into the third and fifth layers.

5. The changes were similar to those of 4 of this group but were more pronounced.

Control.—The meninges and vessels were slightly thickened. The nerve cells in all layers appeared normal.

From these microscopic examinations of the cortex it seems that one small dose of morphine (class B) or even three large doses (class A) have no effect on the nerve cells. Five moderately large doses (class C), however, caused necrosis of the nerve cells in the fourth layer (Vogt's classification). All of the animals who were poisoned over a longer period showed chronic or acute changes in the nerve cells. When two

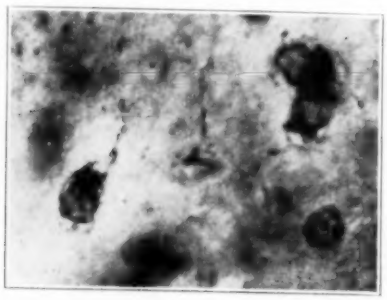

Fig. 6.—Oligodendroglia from group A, swelling + + +. Dog A_2 received 389 mg. per kilogram; it was killed after twenty-four hours.

Fig. 7.—Oligodendroglia from group E, showing marked swelling, + + ++. Dog E_3 received 111.1 mg. per kilogram; it was killed after seventeen and a half days.

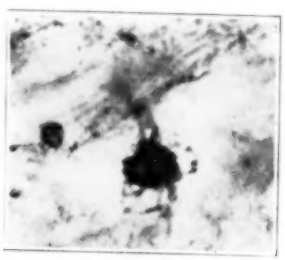

Fig. 8.—Oligodendroglia from group E, dog E_4, swelling + + + +.

small doses were given daily for eleven days (class D) many of the cells were pyknotic and showed satellitosis; larger and increasing doses over a period of seventeen days (class E) caused more acute and more widespread changes, degenerating neurons being found in the third, fourth and fifth layers.

COMMENT

In a comparison of the various groups the important factors are: duration of drug administration, total dosage and degree of cellular degeneration.

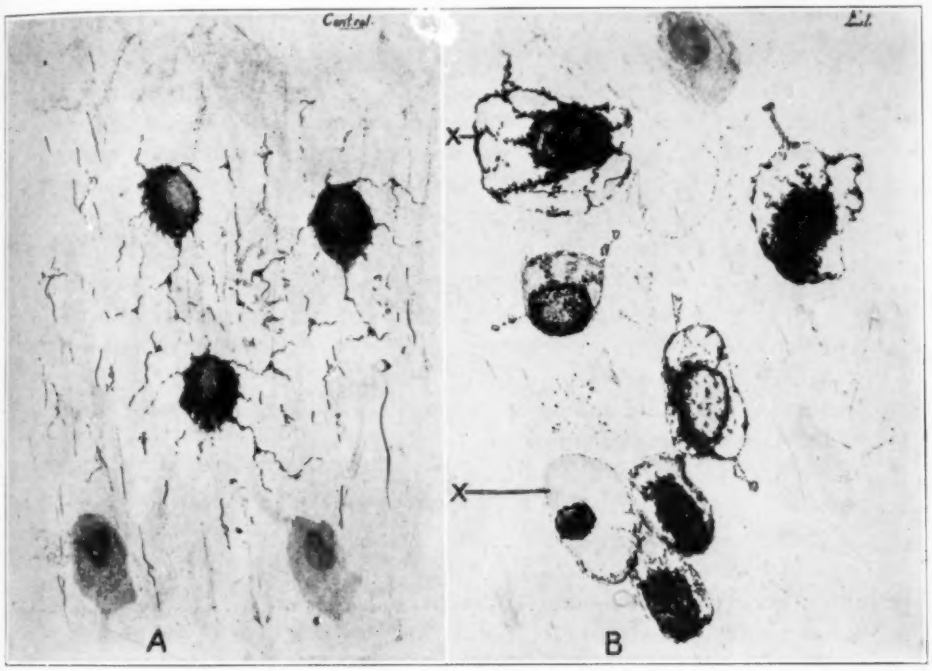

Fig. 9.—Sketch contrasting normal oligodendroglia *A* with swollen oligodendroglia *B*. (Dog E_1 received 118.9 mg. per kilogram; it was killed after sixteen and a half days.) Cells marked *X* show the most extreme swelling encountered. Such cells were unusual, and but infrequently seen.

A comparison of classes A and D shows that although the total dosage in D (26.4 mg. per kilogram) was less than in C (34.2 mg. per kilogram) the period of intoxication was much longer and the swelling greater. That smaller doses over long periods can have a greater effect than large doses over short periods is even more strikingly illustrated by comparing the groups A and E. Dogs in group A received a much greater quantity of morphine sulphate (290 mg.) in twenty-four hours than the dogs in group E (108.2 mg.) received in seventeen days.

Yet the oligodendroglia degeneration was farther advanced in E than in A. Mankowsky [3] similarly observed that the duration of the administration of morphine rather than the amount of drug administered was the important factor in the determination of alterations in the neuron.

When the duration of administration in two groups is the same, the degree of swelling of oligodendroglia is then dependent on the amount of drug given. Classes A and C differed only in total dosage, and there was definitely less swelling in the animals receiving the smaller dose. Two dogs of approximately the same weight on the same dosage over the same period may respond differently. This difference in reaction to the same intoxication is noticeable to some degree in all our animals and may be attributed to a constitutional difference in tolerance.

Two dogs in group C were allowed to recover entirely (nine days). When killed, their oligodendroglia were normal. Swelling of the oligodendroglia was found in other animals of this group killed during the height of the drug's action. This indicates that the swelling, if not too severe, may subside. Recoverability of swollen oligodendroglia is suggested by an earlier observation of Penfield and Cone.[7] The lesions in the nerve cells, however, showed no indication of recovery.

In spite of the sensitiveness of the oligodendroglia, the physiologic reactions to morphine cannot be said to be strictly associated with detectable structural changes or dependent on their presence. Dogs given small doses of morphine (class B) and killed after three hours did not show a definite alteration in the oligodendroglia. These animals did, however, show evidence of the drug's action, such as stupor, initial vomiting, purging and respiratory disturbances.

From this comparison of data it becomes evident that there is a general relationship between duration of intoxication, total dosage and the oligodendroglial swelling. This relationship may be expressed by the equation: $S = \frac{T \times D}{X}$, S being the swelling produced, T the duration of treatment, D the total dose and X the "tolerance," a factor which differs for each animal. It is hardly necessary to mention that the equation is nothing more than an approximate expression. The denominator, for example, cannot be calibrated.

It is also important to recall that the oligodendroglial changes observed in morphine intoxication are not characteristic for this particular drug. We have observed, as have others,[7] that intoxication of various kinds may produce the same type of change.

There are evidences of gross and delicate changes in cellular metabolism in morphine intoxication; loss of weight, acidosis, fluid retention and the presence of abnormal intracellular lipoids have been clinically and experimentally observed. The described swelling of oligodendroglia

may be another manifestation of such deranged cellular metabolism. The chemical and physical changes responsible for the degeneration are not known.

SUMMARY AND CONCLUSIONS

1. Several groups of dogs received injections of morphine sulphate varying in amount from 3 to almost 400 mg. per kilogram. They were intoxicated through single and repeated injections for periods varying from three hours to about two and one-half weeks. At the end of the special period for each group, the animals were killed, and histologic studies of the neurons and interstitial cells were made.

2. The oligodendroglia in all but the very mildly intoxicated animals showed degenerative swelling. Definite swelling of the oligodendroglia occurred in animals in which the microglia and astrocytes appeared normal.

3. The observed alterations in oligodendroglia are not specific in that they result from morphine sulphate only, but they are similar to those caused by other intoxicants.

4. The degree of degenerative swelling of the oligodendroglia is chiefly dependent on the total dosage and duration of administration of the drug.

5. If the degeneration is not too advanced, complete structural recovery may occur when the administration of the drug is discontinued.

6. The oligodendroglia may appear normal in animals mildly yet sufficiently intoxicated to present the physiologic effects of the drug. Hence, though the gap between function and structure has been narrowed through the better staining of these sensitive cells, there is still a great discrepancy between the first recordable change in function and the first visible change in structure of the central nervous system.

ABSTRACT OF DISCUSSION

Dr. P. Bailey, Boston: It seems to me rather unusual that the oligodendroglia should show such marked changes without any changes in the other elements of the nervous system. That simply means that the methods are not delicate enough to detect them. The microglia cells which Dr. Wolff showed seemed a little sick. If that is the type of microglia cell found in his brains, I should say the microglia was also intoxicated, because the lateral spines were absent, and that was not due to an imperfect impregnation.

Dr. W. Freeman, Washington, D. C.: The oligodendroglia would seem to be the most sensitive element in the nervous system and therefore a very good cell by which to judge the pathologic changes that are going on. The acute swelling might be interpreted from the standpoint of general pathology as hydropic degeneration, which is one of the commonest manifestations of disease in the nervous system. The fact that morphine intoxication produced this effect on the oligodendroglia, with minor or even negative changes in the other cells, indicates the importance of a study of the oligodendroglia in various conditions of the nervous system.

The cause of this swelling probably refers back to the general physicochemical changes which might in this case be due to the lowered intake of oxygen through the depression of the respiratory centers.

Dr. A. Ferraro, New York: I have also been surprised and for that matter in sympathy with what Dr. Bailey has stated as to the absence of reaction on the part of the microglia. Although I concur with Dr. Freeman in his statement that the oligodendroglia is one of the most sensitive elements, I think that after a period of thirteen days some change should have occurred in the microglia cells. As a matter of fact, I have experienced, in cases of illuminating gas poisoning, that in the early stages there is a slight swelling of the oligodendroglia, but often, accompanying these changes, I have found a swelling of microglia closely resembling the type of acute swelling of oligodendroglia. I agree with Dr. Wolff as to the reversibility of the acute swelling of the oligodendroglia. In the experimental work on the reaction of the oligodendroglia to injury of the brain, Dr. Davidoff and I have been unable to detect any swelling of these cells a few days after the injury; neither did we detect any swelling of the microglia.

On the other hand, we have been able to follow transitory stages between swollen oligodendroglia and compound granular corpuscles which fact has not been pointed out in Dr. Wolff's paper. In connection with this it seems to us as if acute swelling and transformation into scavenger cells are two distinct processes depending on the severity of the lesion. If the lesion is mild and consists of a simple disruption of the osmotic or colloidal equilibrium between the cell body and its surrounding, substances from the nervous tissue, mainly its water component, penetrate into the cell leading to a swelling and at times eventually the death of the element. If the lesion is somewhat severe, the protein material may also be imbibed into the cell and the mucine product of disintegration may thus be detected. Finally, if the lesion involving the nervous tissue is even more severe leading to the fat disintegration of the elements of the myelin sheaths and of the interstitial tissue, the fat product of disintegration may become located in the oligodendroglia cells, among others, which thus undergo a gradual transformation into compound granular corpuscles.

Dr. Wolff: It has been our feeling from the first that it is extremely unlikely that the oligodendroglia should be unique in their responsiveness to intoxication. It seems to us altogether reasonable that all the tissues in the body and certainly the microglia, astrocytes and the neurons should be altered by the poison, but with Dr. Bailey, we feel that at the present time our methods do not permit us to be certain of these subtle changes, except in a few types of cells. We do not feel capable of differentiating from the normal the various changes seen in the other types of cells of the central nervous system; not that the degenerative alterations have not occurred, but that our methods of detection are not senstive enough to enable us precisely to define the abnormal.

We stained the tissues with Grynfelt's mucicarmine and were unable at this stage of the oligodendroglia degeneration to demonstrate the presence of mucin, such as was observed by Drs. Bailey and Schaltenbrandt in their study of late degenerative changes of oligodendroglia.

As to the relation of the oligodendroglia to the gitter cells, I may say that there is no evidence in these or other experiments that would lead to the inference that there is a transmutation of oligodendroglia to what we know as gitter cells. We are, however, familiar with a series of degenerative changes of oligodendroglia ending in the destruction of the cell and giving the tissue a diffusely vacuolated appearance. From such evidence as we have it seems prob-

able that in the advanced stages of oligodendroglia degeneration the cytoplasmic expansions degenerate, the cell membrane ruptures and the nuclei disappear, leaving a hole at the former site of the cell. We have no evidence of migration of oligodendroglia.

In answer to Dr. Freeman's question as to the probable etiology of the swelling of oligodendroglia, we have only a hypothesis to offer. We believe that the changes are the result of a general metabolic disturbance rather than the specific effect of morphine sulphate on this special tissue.

DIABETIC EXOPHTHALMIC DYSOSTOSIS*

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This unique symptom complex, beginning in childhood and characterized by the triad of diabetes insipidus, exophthalmos and disease of the membranous bones, is of special interest in its relation to the study of the central vegetative and endocrine mechanisms grouped in the parainfundibular portion of the hypencephalon. It assumes added importance because of its bearing on certain dysostoses, which until now have been regarded as separate entities, but which in all probability are allied forms; namely, the hereditary cleidocranial dysostosis of Marie and Sainton,[1] and the familial craniofacial dysostosis described by Crouzon and recently studied by Debré and Petot.[2] More recently, the kinship was further extended to include the surprising relationship with the xanthomatous diathesis, which Rowland[3] attempted to identify as a lipoid disorder of the reticulo-endothelial system.

A survey of the literature reveals fourteen other cases with the syndrome to be discussed, the first one described by Schueller,[4] in 1915, under the title of "pituitary dysostosis." The disease occurs chiefly in children and in most instances is progressive. The etiology is unknown, although the incidence of previous infection is high. Disordered metabolism may play an important part.

REPORT OF A CASE

Clinical History.—C. C., an Italian boy, aged 3½, was admitted to the neurologic service on July 19, 1927, with a history of exophthalmos, polydipsia and polyuria of at least one and a half years' duration. The ancestry of the child revealed no pertinent facts. The father and mother were born in Girgenti,

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* From the Neurologic Service of Dr. Israel Strauss at the Mt. Sinai Hospital.

1. Marie, P., and Sainton, P.: Sur la dysostose cleido-cranienne héréditaire, Rev. neurol. **6**:835, 1898.

2. Debré, R., and Petot, C.: Une famille de sujets atteints de dysostose cranio-faciale, Bull. et mém. Soc. méd. d. hóp. de Paris **50**:1221, 1926.

3. Rowland, R. S.: Xanthomatosis and the Reticulo-Endothelial System; Correlation of an Unidentified Group of Cases Described as Defects in Membranous Bones, Exophthalmos and Diabetes Insipidus (Christian's Syndrome), Arch. Int. Med. **42**:611 (Nov.) 1928.

4. Schueller, A.: Ueber eigenartige Schädeldefekte in Jugendalter, Fortschr. a. d. Geb. d. Röntgenstrahlen **23**:12, 1915-1916.

Sicily, and married at the ages of 23 and 20, respectively. Both parents were living and well; the mother, a nervous woman, belonged to the linear asthenic type, whereas the father was short and stocky and presented many of the features of hypothyroidism. There had been no miscarriages. There was no history, in the immediate or collateral family, of any disease of the bones, dwarfism, diabetes insipidus, exophthalmos, syphilis, epilepsy or alcoholism. There was one other child, a boy, aged 1 year, thus far apparently normal.

The patient was born on April 20, 1924, following a full term pregnancy, which was normal in every respect except for the fact that the mother had been subject to a good deal of worry and tension. She had no symptoms to suggest diabetes insipidus or any disease of the bones. Labor was protracted but not dry; the vertex presented.

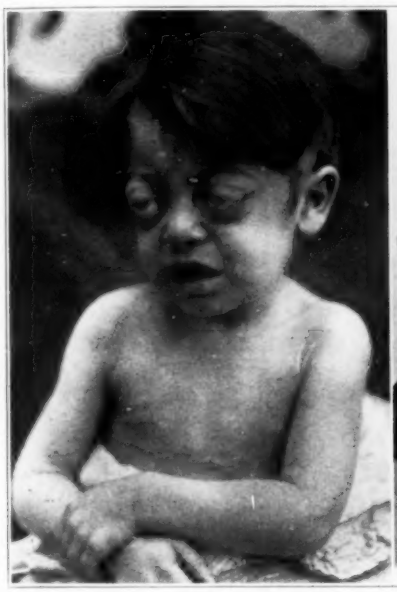

Figure 1

Figure 2

Fig. 1.—The extreme degree of exophthalmos, more marked on the right side, should be noted.

Fig. 2.—The patient standing on the right side of his brother is undersized but well proportioned. Both are the same height, although the former is two and a half years older than his brother.

At birth, the patient weighed 9½ pounds (4.3 Kg.); he suffered apparently from asphyxia neonatorum and convulsions which disappeared soon after birth. There were no paralyses or skin eruptions. The early development was normal. The child was breast fed until the age of 1½ years. He began to walk at 17 months and could say "ma" and "pa" at 12 months. The parents did not know at what age he first stood or sat up, or when he first took notice of things. The first tooth appeared at 3 months, the second tooth at 5 months and the others for that age at 1 year. At the age of 8 months, the patient had an attack of bronchitis, which subsided in from two to three weeks; thereafter, he was subject to recurrent

attacks every two or three months until he was 1½ years of age, when the last attack terminated in measles. Whether the child had any fever during these attacks could not be accurately elicited. The child had not been vaccinated.

For one year and a half prior to admission, the parents noticed that the patient's eyes were gradually becoming more prominent, the right slightly more than the left (fig. 1); that he was drinking and passing large amounts of water, and that he was not growing. During this time he became weaker and more irritable, and his appetite diminished. At no time did the child manifest any visual or auditory disturbances or bladder or rectal incontinence, or give any evidence of headache, motor impairment or mental abnormality. Whether there was any impairment in the growth of the bones at or before the onset of the exophthalmos or diabetes insipidus could not be determined.

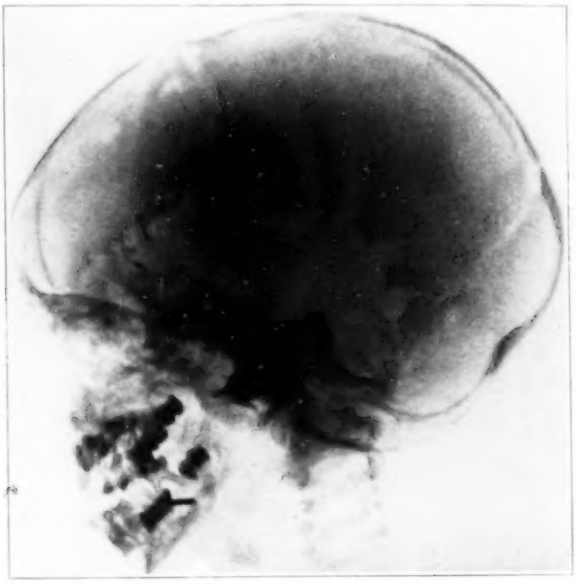

Fig. 3.—Lateral view of the cranium, showing the large sharply defined bone defects in the inferior portion of the frontal and temporal regions. The sella turcica is normal.

Examination.—The patient was well proportioned, but undersized (fig. 2), measuring 78 cm. and weighing as little as 22 pounds, 11 ounces (10.3 Kg.). Attitude and posture were both normal. There were no abnormal movements of any kind.

The mental status revealed an alert child, who took a normal interest in his environment, played with the other children and under the patient training of nurses improved considerably in personal habits.

The most striking observations were noted in the head. The face was flat, especially in contrast to the extremely bulging eyes (fig. 1). The fontanels were closed. The vault of the skull sloped quickly to the sides. No stigmas of degeneration were evident. The ears and nose were normal. The teeth and throat appeared healthy.

That we were dealing with an unusual condition was emphasized by the large soft temporal defects which could be palpated on either side. These soft areas were not tender. The stereoroentgenograms of the skull showed that the process involved exclusively the membranous bones and consisted of a number of large, sharply defined defects of decalcification, especially in the inferior portion of the frontal and temporal areas, as if the bone had been eaten away by a rongeur (figs. 3 and 4). Repeated roentgen examinations were made for a period of eight months; these showed the process finally extending to the membranous bones of the face and vault (fig. 5). In all the plates, however, the sella turcica was normal. Roentgen examination of the rest of the skeletal system gave entirely negative results.

The appearance of the eyes was most unusual. There was an extreme degree of exophthalmos, more marked on the right side than on the left (fig. 1). Ocular

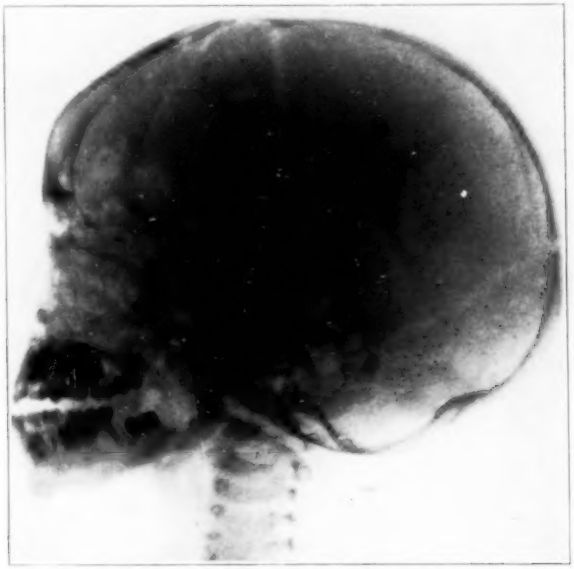

Fig. 4.—The same view as in figure 3, but from the opposite side. The areas of decalcification are sharply defined but less extensive.

tension, however, was normal. The von Graefe and Stellwag signs were easily elicited. So pronounced was the exophthalmos that the eyes appeared to be in constant danger of falling out of their sockets, especially when the child cried. On one occasion the right eye actually rolled out over the lower border of the orbit.

The chest was flat and showed a wide bilateral flare, with a suggestive rachitic rosary on both sides. The heart and lungs were normal. The neck was normal. The pulse rate varied between 80 and 112; the average was 100. The respiratory rate was normal. The temperature ranged between 97 and 100 F., with a tendency to a low level in the last few weeks. The blood pressure was: systolic, 96; diastolic, 50.

The abdomen was large and distended, "pot-belly" in type. The liver, spleen and kidneys could not be palpated. No abnormal masses were seen or felt. The genitalia were normal. The skin was apparently normal.

Neurologic Examination.—1. The attitude and movements were normal. 2. Mental status: The chronologic age was 3½ years; the mental age by the revised Stanford test was 2 years and 10 months. When the patient first entered the hospital, he knew few English words; but during the stay in the hospital he showed an aptitude for learning and acquired many words, understanding commands much better. 3. The cranial nerves were entirely normal. Despite the severe exophthalmos there was no visual impairment. The fundi showed slight blurring of the nerve margins on the left, within normal limits. The pupils were normal. Speech was normal. 4. The motor system was entirely normal. There was no paralysis or atrophy of any of the muscles. Muscle tone and volume were

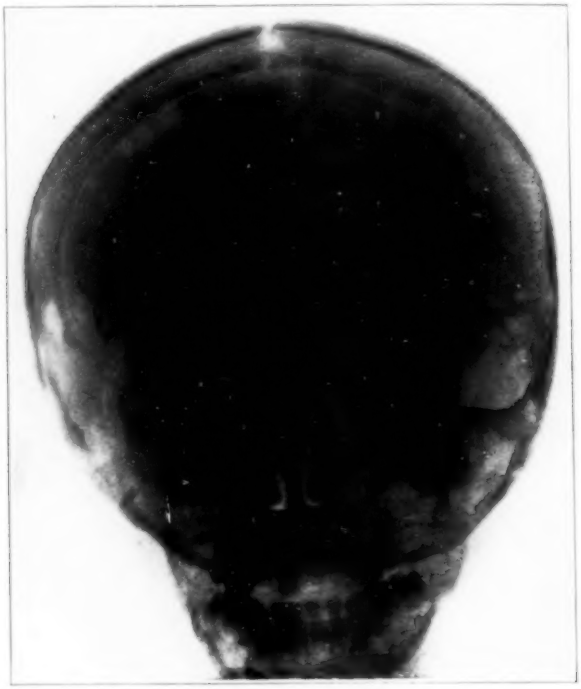

Fig. 5.—Frontal view. The disease has invaded the membranous bones of the face. The orbital defects are striking. In the vault, a few small circumscribed areas of absorption are also seen.

good. Coordination was in no way impaired. 5. Reflexes: The deep reflexes were active and equal. The superficial reflexes were all present. There were no pathologic reflexes, except for a bilateral extensor plantar response. 6. The sensory system was objectively normal. 7. No trophic disturbances were noted; the hair and nails were normal. All joints were normal. The bones revealed the defects already noted. 8. The outstanding vegetative-endocrine disturbance was the defect in water metabolism, consisting of a marked polyuria and polydipsia. The water intake on admission averaged 6,000 cc. daily; the output was also large but difficult to measure accurately. The water metabolism was markedly influenced by daily injections of solution of pituitary which reduced the intake to 2,000 cc. Vesical and rectal functions were normal.

There was also a glycoregulatory disturbance, in the form of increased tolerance for carbohydrates, but with no signs of adiposogenital dystrophy.

The following negative observations are important: There was no increase in intracranial pressure. The Wassermann reactions of the blood and spinal fluid were negative. The chemistry of the blood as to calcium, phosphorus and chlorides was normal, which was surprising in view of the rapid progress of the dysostosis. The basal metabolism was not studied because of the child's unruliness.

Special Examinations.—1. Radiography, on July 20, 1927, revealed the remarkable picture in the skull already noted (figs. 3, 4 and 5). 2. Examination of the urine revealed a low specific gravity, which varied between 1.001 and 1.004. Otherwise it was normal. 3. The blood count showed: hemoglobin, 68 per cent, and white cells, 8,200, of which 53 per cent were polymorphonuclears and 37 per cent mononuclears. After a short stay in the hospital, the hemoglobin content rose to 75 per cent. 4. Chemistry of the blood revealed: calcium, 10 mg.; sugar, 78 mg.; chlorides, 4.35 mg., and phosphorus, 3.5 mg. The Janney test, made on several occasions, revealed a high sugar tolerance; absorption was prompt, the maximum hyperglycemia being noted in one-half hour. 5. The cerebrospinal fluid was under normal pressure, was clear, contained five cells per cubic millimeter, and gave a negative globulin reaction. A second lumbar puncture, several weeks later, also gave negative results. The result of a Pirquet test was negative.

Course.—1. The exophthalmos was progressive and increased steadily. The exophthalmometric readings were: Aug. 22, 1927, right 22, left 22 (at 82); September 1, right 24, left 23 (at 82), and November 11, right 27, left 27 (at 85). The ophthalmologist reported difficulty in taking these readings at such a high figure.

2. Through the generous cooperation of the roentgen-ray department, we were able to note the progress of the dysostosis by repeated roentgen examinations.

The roentgenologist reported: "On the right side (of the skull) there is seen marked bone absorption especially in the frontal and parietal regions, extending upward from the orbital plate for an area about the size of an orange. The borders are sharply delineated and irregular. It also extends downward to the walls of the right antrum. In the region of the left antrum, but much less extensive, a similar process is seen. In the vault a few small circumscribed areas of absorption are seen." Examination of the pelvis, hips and long bones failed to show any abnormality.

Reexamination of the skull one month later showed an advance in the decalcification, especially in the vault; several weeks later, the rarefaction of the bones was seen to be much more extensive, especially on the right side, the lesion occupying an area 4 by 3 inches (10.16 by 7.6 cm.).

The sella turcica was normal in all plates. Roentgen examination of the father's skull failed to show any abnormalities of the cranial bones. The sella turcica was normal in size and shape. The roentgen examination of the brother's skull also showed no abnormality.

3. The diabetes insipidus, with regard to the water intake and output, was markedly influenced by daily injections of 1 cc. of solution of pituitary. The intake of 6,000 cc. daily on admission dropped, three days after the foregoing treatment was instituted, to approximately 2,000 cc. daily, and remained at that level for several months with occasional exacerbations. Two weeks previous to discharge, the solution of pituitary was discontinued and the water intake and output remained at 3,300 cc. and 2,300 cc., respectively. It was difficult to measure the output at first, because the patient wetted the bed and some time elapsed before he learned to regulate his habits.

4. The study of the chemistry of the blood showed little variation from the normal. Despite the rapid progress of the dysostosis, the figures for phosphorus and calcium remained normal on a standardized diet.

The calcium in the blood, which was 10 mg. on admission, increased to 12 mg. following a course of treatment with ultraviolet light, calcium lactate, cod liver oil and parathyroid extract collip; the phosphorus likewise rose from 3.5 to 5.7 mg., despite the progressive course of the decalcification process.

5. The patient made little clinical improvement, except for the reduction of the intake and output of water. The weight during the stay in the hospital fluctuated between 22 and 25 pounds (10 and 11.3 Kg.), being 23 pounds and 6 ounces (10.55 Kg.) on discharge. The child's behavior improved steadily, owing to the training given by the nurses.

Treatment.—Various methods of treatment were tried. The only one of value was the solution of pituitary which, administered daily, influenced the water metabolism as previously noted.

Bearing in mind that the dysostosis might be allied to rickets, we decided to employ radiation with ultraviolet light. It was given intensively for a period of several weeks; during part of this interval, parathyroid extract collip, calcium lactate and cod liver oil were administered, but no improvement was noted that could be attributed to any of these agencies; in fact, the decalcification continued to progress.

CASES REPORTED IN THE LITERATURE

The syndrome was first described by Arthur Schueller, who regarded it as a manifestation of hypophyseal disturbance. The following is a summary of the fourteen cases reported in the literature:

CASE 1 (Schueller [4]).—A boy, aged 16, was apparently healthy in his first year of life but ceased growing at about school age. At the age of 4 years, he had otitis on the left side which left the hearing on that side impaired. Three months before admission, the patient noticed that the left eye was more prominent than the right and that he had recently been seeing double on looking to the side.

Examination revealed that the boy was undersized, 137 cm. in height, with a dolichocephalic head, protrusion of the left eyeball and the syndrome of dystrophia adiposogenitalis. X-ray examination of the skull revealed large areas of rarefaction, the largest being in the left parietal bone, with sharp edges and irregular form; the central part appeared more strongly defined than the periphery, suggesting that the defect was shallower at the edges. Similar defects, but less marked, were present in the left frontal and temporal areas; there was also some occipital involvement. The sella turcica appeared small; the dorsum sellae was intact.

A diagnosis of tumor of the brain was made at first, and later that of multiple angiomas of the skull, because the patient had a telangiectatic nevus on the right forearm. There were no symptoms of tuberculosis or syphilis. No reference is made to the question of diabetes insipidus.

CASE 2 (Schueller [4]).—A girl, aged 4½, with a history of whooping cough at the age of 1½ years, suddenly developed exophthalmos on the left side at the age of 2 years, and, one month later, exophthalmos on the right, also acute. There was, in addition, marked polyuria and polydipsia, as much as 8 liters per day. The Wassermann reaction of the blood was negative. Roentgen examination of the skull showed extensive defects at the base and involvement of both orbital roofs; the sella turcica was also markedly impaired, only the dorsum sellae being present. In the pelvis, there was a small round defect in the right ilium.

CASE 3 (Hochstetter, cited by Schueller[5]).—A man, aged 38, "with symptoms of pluriglandular insufficiency; impotence, polydipsia, exophthalmus, leanness of highest degree. The skull showed multiple large defects." This case came to autopsy and showed multiple sclerosis of the endocrine glands; the pituitary gland was absolutely atrophic and sclerosed. "In the defects of the skull was a soft tissue showing neither the character of a tumour nor an inflammatory process."

CASE 4 (Alberti, cited by Schueller[5]).—A man, aged 21, with exophthalmos, diabetes insipidus and large defects of the skull, the os pubis and the femur. The patient was a dwarf, who ceased to grow after his thirteenth year.

CASE 5 (Christian[6]).—A girl, aged 5, was well and normal in every way up to the age of 3 years; at that time, her teeth began to decay and became loose and the gums became swollen and tender. One-half year later, the right eye became prominent and signs of diabetes insipidus appeared; this condition increased gradually in intensity until both eyes protruded markedly and the intake of water was 9 quarts a day, with urination every hour.

Physical examination revealed the typical defects in the skull bones and marked exophthalmos. The Wassermann reaction of the blood was negative. Basal metabolism showed a moderate decrease, which was attributed to the disturbance of pituitary function.

The roentgen examination showed "very extensive defects in the skull bones, slight but similar changes in the flat bones of the pelvis, and a quite normal appearance and normal stage of ossification and development of all other bones in the body." The most extensive defects were in the anterior half of the skull, especially in the frontal, orbital and parietal plates; only small defects were present in the occipital bone; "the defects represent a complete loss of all bone substance capable of throwing any distinct shadow characteristic of bone. . . . The sella turcica seems somewhat enlarged and slightly flattened."

CASE 6 (Grosh and Stifel[7]).—A girl, aged 7, a full term baby and normal until the second year became weak and did not develop in size and weight as did the other children. At 6 years of age a tooth became infected; this was followed by a discharge from the left ear and an infection of the left mastoid which was opened and drained. "A month after leaving the hospital, i. e., seven weeks after the mastoid operation, she suddenly developed a marked thirst and polyuria, so that in a few days she was taking as much as four quarts of water during the night and was passing about one and one half gallons of urine in twenty-four hours."

The patient was a dwarf and showed exophthalmos on the left side. The x-rays revealed a normal sella turcica with large areas of rarefaction or complete absorption scattered all over the skull, including the bones of the orbit. There was also an area of absorption in the left ilium. Here, as in the cranial defects, there was complete absence of lime salts. The long bones, the vertebrae and the carpal and tarsal bones were not involved.

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5. Schueller, A.: Dysostosis Hypophysaria, Brit. J. Radiol. **31**:156, 1926.

6. Christian, H. A.: Defects in Membranous Bones, Exophthalmos, and Diabetes Insipidus; an Unusual Syndrome of Dyspituitarism, Contrib. Med. & Biol. Research **1**:390, 1919.

7. Grosh, L. C., and Stifel, J. L.: Defects in the Membranous Bones, Diabetes Insipidus, and Exophthalmos, with Report of a Case, Arch. Int. Med. **31**:76 (Jan.) 1923.

The authors stated further that the changes were unlike those found in osteitis fibrosa, bone cysts, Paget's disease, syphilis, tuberculosis and sarcoma.

CASE 7 (Hand[8]).—The patient was a boy, aged 3, with a sudden onset of diabetes insipidus eight weeks before admission. There was a history of enterocolitis at 5 months of age and of both croup and measles at 2 years.

The patient was undersized and had exophthalmos, a rachitic rosary, a distended abdomen and a large spleen and liver. The case came to autopsy, but there was no detailed study; the defects in the skull were noted and superficially regarded as tuberculous.

CASE 8 (Hand[8]).—The patient was a boy, aged 4, "from whom there had been removed at 2 years of age a tumor-like swelling in the left parietal region, absence of the bone beneath it down to the dura being noted; the pathologic report of the tissue removed was 'no gumma, no sarcoma, slight degree of inflammation, mainly myxomatous change.' Since then other swellings have appeared and exophthalmos, greater on the left, has taken place, but as yet no polyuria."

Roentgen examination of the skull showed large areas in the calvarium without bone. The sella turcica was not involved.

CASE 9 (Kay, cited by Hand[9]).—A boy, aged 7, was well and normal until the age of 4 years, when he had an attack of scarlet fever which was complicated by otitis on the right side. From five to six months later, the gums began to separate from the teeth; this was followed by a gradual loss of most of the teeth. About the same time, the mother noticed a soft spot on the head. Eighteen months prior to admission exophthalmos appeared, and four months later diabetes insipidus. The bones of the body were normal, except for defects in the cranium and in the lower jaw which had lost its bone salts.

CASE 10 (Denzer[10]).—A boy, aged 5½, two months after a tonsillectomy at the age of 4½ years for repeated attacks of sore throat, had "small tender spots on the head." One year after the onset of the disease, diabetes insipidus and exophthalmos developed. The "soft spots on the head" persisted, and in these areas no bone could be felt. The occipital and parietal regions were involved. The author stressed the fact that the bone defect anteceded the appearance of the first signs of diabetes insipidus by one full year.

CASE 11 (Thompson et al.[11]).—This case is important because of the autopsy study. A boy, aged 9, had a history of excessive thirst and frequent urination. Birth, growth and development had been normal. Chickenpox and scarlet fever in a mild form, without complications, had occurred in childhood. Fourteen months

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8. Hand, A.: Defects of Membranous Bones, Exophthalmos and Polyuria in Childhood; Is It Dyspituitarism? Am. J. M. Sc. **162**:509, 1921.

9. Kay, T. W.: Acquired Hydrocephalus with Atrophic Bone Changes, Exophthalmos and Polyuria, Penn. M. J., 1905-1906, vol. 9; cited by Hand (footnote 8).

10. Denzer, B. S.: Defects in the Membranous Bones, Diabetes Insipidus and Exophthalmos, Am. J. Dis. Child. **31**:481 (April) 1926.

11. Thompson, C. O.; Keegan, J. J., and Dunn, A. D.: Defects of Membranous Bones, Exophthalmos and Diabetes Insipidus: Report of a Case with Necropsy, Arch. Int. Med. **36**:650 (Nov.) 1925.

before admission, the patient suffered a severe attack of measles which lasted for three weeks and was followed by slight looseness of the teeth and soreness of the gums. Six months later, excessive thirst and urination appeared suddenly, persisted for several days and then disappeared. At this time, his mother noted a soft spot on the right side of the head. About one year after the attack of measles, the polydipsia and polyuria returned, so that the patient was passing from 6 to 12 liters of urine daily.

Examination revealed prominent eyes and defects of the bone. The Wassermann reactions of the blood and spinal fluid were negative. The basal metabolism was normal.

Roentgenograms of the skull showed involvement of the vertex, the frontal region, the superior orbital plates and both maxillas. The sella turcica was normal. The pelvic bones showed lesions similar to those in the skull. The femurs and the body of the fourth lumbar vertebra were also impaired. Later, the process spread to the cervical vertebrae, the scapulae and all the ribs.

Autopsy was performed. The cranium, owing to the defects in the bone, was for the most part membranous. This cranial membrane consisted of a "typical dense white fibrous tissue, with no evident lines of cleavage between the dura proper, the endosteum, the absorbed cranial bone and the periosteum." The tissue obtained from the seat of active bone destruction contained foreign body giant cells, polymorphonuclear leukocytes and plasma cells. Histologic sections of this tissue at the edge of the bone showed a highly cellular tissue composed chiefly of large cells with eosinophilic cytoplasm and large reticular nuclei. "In many places, particularly at the bone border, these cells appeared to have fused to form large, multinuclear, foreign body giant cells."

Serial sections of the tuber cinereum, hypophysis and adjacent structures were made. The tuber cinereum revealed dense fibrosis with areas of active inflammation. It contained multinuclear giant cells of the same type as those found at the margin of the bone. In the brain tissue adjacent to the tuber cinereum there was perivascular infiltration. The hypophysis, which with its dural envelop was removed intact, was reddish and of normal size. The infundibulum at its junction with the gland was of normal size and appearance. On histologic section there was a slight subacute inflammation of the pars posterior of the pituitary gland. The base of the infundibulum showed a considerable, dense white fibrous stroma. The other ductless glands were normal. The testes, which were grossly normal, were not studied histologically. Examination of the other systems revealed a chronic interstitial fibrosis of the lungs, hypertrophy of the heart, chronic passive congestion of the liver and spleen and hypertrophy of the kidneys and bladder.

The authors came to the following conclusion: "The histopathologic studies point to an inflammatory rather than to a degenerative or a primary metabolic process. The absence of a material pathologic condition in the anterior lobe of the hypophysis excludes it as a factor in the bony defects. The relatively negligible changes found in the pars posterior and the fact that their apparent origin was more recent than those changes found in the tuber cinereum, in the bones, and in the lungs eliminates the pars posterior as an important factor in pathogenesis. . . . The changes in the stalk appeared of more recent origin, lessening the possibility of its participation in the causation of the syndrome. . . . The lesions in the tuber cinereum were of the same character and apparent maturity as the lesions in the bone and in the lungs, which suggests that these lesions were produced by the same agent at about the same time."

Case 12 (Kyrklund[12]).—This case is also important because of the postmortem study. A girl, aged 12, a dwarf, had the typical defects of the skull, exophthalmos, adiposogenital dystrophy and diabetes insipidus. There was a history of protracted and difficult labor. At the age of 2 years, following a cough, the child became thin. The onset of the present illness with the signs of diabetes insipidus occurred at the age of 4 years. Three years later, the exophthalmos and first signs of adiposogenital dystrophy appeared. The roentgen examination on admission revealed the usual bone defects in the cranium; the sella turcica was normal.

Autopsy: Histologic examination revealed no abnormality in the suprarenal glands, ovaries or hypophysis. However, sarcoma-like foci were found in the region of the hypophysis, in the cerebral meninges, in the skull and in one kidney. There was also some evidence of an inflammatory process. The lungs showed a healed tuberculosis.

Case 13 (Rowland[5]).—A boy, aged 5 years and 2 months, had a history of a mild facial eczema and a small abscess on the scalp at 11 months, otitis media at 12 months, and nasal diphtheria at the age of 1½ years. "At the age of two years, following a mild attack of measles, the patient did not appear as well as usual. Six months later his tonsils and adenoids were removed. A soft swollen area was found on the back of his head at this time, which, it was thought, might have been due to a fall down some steps. As he did not complain of pain, a physician was not consulted until the child was 3 years and 9 months of age, when another swelling and soft spot appeared in the right temporal region; the mother ascribed this to his striking his head against the corner of a table. Examination at this time showed a marked degree of exophthalmos and strabismus. The vision and eyegrounds were normal. The alveolar processes were swollen and tender, and most of the teeth were loose and infected, producing a foul odor to the breath. He had already lost a number of teeth, ten having been extracted at one time. There was a slight serous discharge from both ears, with questionable mastoid tenderness.

"Roentgen examination showed multiple cranial defects involving both tables of the skull and one large defect in the occipital region of the skull where erosion of both tables was complete, suggesting a metastatic process probably from sarcoma."

The boy was considerably undersized for his age. Diabetes insipidus was not present. "Generalized xanthoma of a so-called visceral type was found."

Autopsy.—In addition to other changes noted, the following were of particular interest: "The bones showed atypical marrow. There was reticulo-endothelial hyperplasia with many multinuclear giant cells and many lipoid cells. Rarefaction of the bony trabeculae was found. (The bone absorption resembled that seen in some cases of osteomalacia.)

"The dural plaques consisted of masses of lipoid-containing cells of reticulo-endothelial type resembling xanthoma. Throughout were numerous multinuclear giant cells. In old tissue of the dura were numerous small calcareous concretions. In lipoid masses were areas of cholesterol crystals formation, with cholesterol clefts and with many multinuclear giant cells. Giant cells, evidently foreign body giant cells, surrounded the cholesterol crystals. These plaques did not suggest infectious granuloma but resembled xanthoma or masses of cells of the xanthoma type, probably consisting of proliferated reticulo-endothelial cells with cholesterolosis. Fat stain showed cells to be loaded with lipoids."

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12. Kyrklund, R.: Beitrag zu einem seltenen Symptomenkomplex (Schädelerweichungen, Exophthalmus, Dystrophia adiposogenitalis, Diabetes Insipidus), Ztschr. f. Kinderh. **41**:56, 1926.

Curiously enough, "sections from the brain did not show any pathologic change except slight edema."

CASE 14 (Rowland[3]).—A boy, aged 3 years and 11 months, had been well, apparently, during the first year of life. About the age of 2 years, "he became irritable, complained of a sore mouth, began to ask for water frequently and to pass large amounts of urine."

At the age of 22 months, he fell from a rocking chair and struck his head. At 26 months, he had a second fall, after which considerable swelling appeared over the frontal bone. Suppurative otitis media appeared at this time. Symptoms of marked diabetes insipidus appeared.

Examination.—The patient showed moderate dwarfism, exophthalmos and diabetes insipidus.

X-Ray Examination.—"The skull shows evidence of multiple cranial defects. One large defect involved the entire base of the skull and frontotemporal region on the right side. The process has entirely destroyed the floor of the sella, only the anterior clinoid processes and dorsum sella remain as landmarks. A large defect also appears in the left parietal region near the vertex of the skull with a smaller one in the vertex. There is evidence of involvement of the fifth rib on the right side in the posterior axillary region. No involvement of the long bones, but an area of decreased density in the right ilium."

In this case, at the time when there was a moderate increase of cholesterol in the blood, roentgen examination showed a moderate increase also in the destruction of bone. "During the past year, while the blood cholesterol has been low, there has been a most remarkable lessening of the bone destructive process as shown by the roentgenograms. The defect in the bone at the vertex of the calvarium has filled in to such an extent that it can only be located with difficulty and the large areas at the base of the skull have been almost entirely regenerated. Coincident with this, the patient, instead of being irritable, is happy and active and is without pain or discomfort. He has increased in height three and one half inches, in contrast to his growth of less than one inch during the preceding twelve months, and the polyuria and polydipsia have decreased."

COMMENT

Analysis of the cases recorded, including the present one, brings to light several pertinent facts in the etiology and pathogenesis of the condition.

Sex.—Of the fifteen cases studied, eleven occurred in males and four in females.

Age.—The youngest patient was 3 years of age, the oldest 38. All but three of the cases occurred in children.

Pathogenesis.—The cause of the disease is obscure, although one cannot overlook the great incidence of antecedent acute infections. In nine of the fifteen cases, there was a definite history of previous infection which seemed to have a pertinent relation to the onset of the disease. In only two cases was there difficult labor. In three cases there was a history of trauma.

The disease is not familial. Whether it is hereditary or not is difficult to say. In most instances the onset occurs within the first few years of life. An inherent germinal defect may predispose the particular systems involved to the exciting agent, whether it be on the basis of an infectious, toxic, metabolic or degenerative process.

Symptomatology.—It is difficult to say which symptom presented itself first. In most instances the mother's attention was first directed to the disease by the presence of exophthalmos. The significance of this symptom is uncertain; it has been regarded as evidence of mechanical pressure exerted on the defective orbital plates by the overlying structures of the brain, although it is difficult to conceive of brain pressure exerting this influence in the absence of increased intracranial pressure; the dura itself would offer considerable resistance. Nor is there evidence to warrant the supposition that the exophthalmos is a manifestation of dysthyroidism. The possibility of a retro-orbital process must also be entertained.

In several of the cases the bone defects apparently antedated the onset of diabetes insipidus, and in two cases the latter was not mentioned. Which of these conditions had priority is difficult to say; the signs of diabetes insipidus would be apt to be noticed much more readily than the defects in the skull, as the latter produced no pain, headache or signs of intracranial pressure. The evidence thus far is insufficient to establish the antecedence of the bone lesion, but to see in that fact an etiologic relationship and to attribute the diabetes insipidus to pressure at the base of the brain by the bone lesions (Denzer,[10] Grosh and Stifel[7]) is inaccurate and unwarranted by the neurologic observations, since there is no evidence of increased intracranial pressure. Denzer[10] argued that the bone lesions "may distort the pressure at the base of the brain enough to disturb the function of the centers situated there," referring particularly to the tuber cinereum. This area, however, is small and it would require an exquisite localization of pressure to involve it alone without impairing the neighboring structures. Furthermore, that region lies in bone of cartilaginous origin, which is not affected by the disease. If this bone were involved, one could then expect some distortion of the overlying brain structures.

Diabetes Insipidus.—In all but two cases, diabetes insipidus constituted a prominent symptom. Until the experimental work of Camus and Roussy,[13] and Bailey and Bremer,[14] it was generally accepted that

13. Camus, J., and Roussy, G.: Polyurie expérimentale par lésions de la base du cerveau: La polyurie dite hypophysaire, Compt. rend. Soc. de biol. **75**:483 and 628, 1913.

14. Bailey, P., and Bremer, F.: Experimental Diabetes Insipidus, Arch. Int. Med. **28**:773 (Dec.) 1921.

the posterior lobe of the pituitary body was responsible for this disturbance. These investigators, however, shifted the responsibility to the tuber cinereum entirely; Bailey and Bremer went so far as to ascribe other hypopituitary symptoms (somnolence and adiposity) to this neurogenic source. Cushing and Maddock,[15] by placing a clip on the hypophyseal stalk "without any appreciable or histologically demonstrable injury of any adjacent structures," obtained "precisely the same results which Bailey and Bremer describe; viz., a prolonged polyuria with subsequent tendency to adiposity."

That the posterior lobe and tuber cinereum constitute an embryologic as well as an anatomic unit is well known. This continuity was further emphasized by the work of Greving,[16] Pines[17] and others, who demonstrated nerve fibers between the supra-optic nuclei of the tuber cinereum and the posterior lobe. In other words, the posterior pituitary lobe, the pituitary stalk and the tuber cinereum in all probability constitute a physiologic unit on the basis of which the diverse views of the different schools can be reconciled.

Unfortunately, the autopsy material in the cases of diabetes insipidus with dysostosis herein reviewed has been inadequate and not studied in the light of recent concepts and better staining methods. In the cases that came to autopsy, one (case 3) revealed absolute atrophy and sclerosis of the pituitary gland; no mention, however, is made of the tuber cinereum. In another, there was no detailed study of any kind. A careful autopsy study was reported in case 11 by Thompson and his associates. These authors regarded the changes in the pars posterior of the hypophysis and in the stalk as negligible and of too recent origin to be significant in the causation of the syndrome. More importance was attached to the older process of fibrosis in the tuber cinereum. In case 13 of Rowland, the brain sections revealed no pathologic change aside from edema. In those cases in which a roentgen examination was made of the sella turcica, it was found seriously impaired in only two cases (cases 2 and 14). Of course, a normal sella may contain a diseased pituitary body. Case 3, with pituitary sclerosis, represents the oldest patient of the group reported. In other words, this suggests the possibility that the glandular atrophy may be a late manifestation. If this interpretation is correct, then the discrepancies between cases 3 and 11 can be explained. The evidence so far is not conclusive.

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15. Cushing, H.: Studies in Intracranial Physiology and Surgery, London, Oxford University Press, 1925, p. 79.

16. Greving, R.: Beiträge zur Anatomie des Zwischengehirns und seiner Funktion, Ztschr. f. d. ges. Neurol. u. Psychiat. **99**:231, 1925.

17. Pines, I. L.: Ueber die Innervation der Hypophysis cerebri, Ztschr. f. d. ges. Neurol. u. Psychiat. **100**:123, 1925.

Growth.—The occurrence of impaired growth in eight of the cases is not without significance and, in view of the other symptoms, raises the question whether it may not be related to the hypophysis and vicinity.

Experimentally, there is direct evidence bearing on this point. The literature is extensive. The results strongly point to the pituitary body as a most important controlling factor in growth (Bremer and others). The work of Evans and Long [18] has been accepted as conclusive that injections of the anterior pituitary gland stimulate the rate of growth. This is in keeping with the excellent work of Smith,[19] who found that hypophysectomy in amphibia produced a slowed growth rate, pigmentary changes, failure to metamorphose and atrophy of the suprarenal cortex and thyroid gland. Many of these defects could be repaired by injections of solution of pituitary and by transplants. His most recent work, the "Disabilities Caused by Hypophysectomy and Their Repair," is convincing and most pertinent to this problem. The experiments were conducted on rats, in which Smith succeeded in ingeniously removing the anterior pituitary lobe without any injury to the pituitary stalk; the technic was so skilful that there was no escape of cerebrospinal fluid.

His conclusions were:

> Hypophysectomy in the rat gives an invariable syndrome, the main features of which are: an almost complete inhibition in growth in the young animal, and a progressive loss of weight (cachexia) in the adult; an atrophy of the genital system with loss of libido sexualis, and in the female an immediate cessation of the sex cycles; an atrophy of the thyroids, parathyroids and suprarenal cortex; and a general physical impairment characterized by a lowered resistance to operative procedures, loss of appetite, weakness and a flabbiness that readily distinguishes the hypophysectomized from the normal animal. It seems unlikely that they can live an average life span. A number operated on at the time of sexual maturity have died about five months later, presenting the physical characteristics which Donaldson gives as indicative of senility. It would seem that there is a premature senility, as noted by Simmonds and others in clinical cases of pituitary atrophy.

Smith found that the disabilities arising from hypophysectomy could be "completely or nearly completely cured by daily pituitary homotransplants."

He also investigated the tuberal (hypothalamic) syndrome in the rat and came to the following conclusion:

> A lesion of the hypothalamic region of the brain (tuber cinereum) gives rise to a syndrome which is distinct from that caused by pituitary ablation. This

18. Evans, H. M., and Long, J. A.: The Effect of the Anterior Lobe Administered Intraperitoneally upon Growth, Maturity and Oestrus Cycle of the Rat, Anat. Rec. **21**:62, 1921.

19. Smith, P. E.: The Disabilities Caused by Hypophysectomy and Their Repair: The Tuberal (Hypothalamic) Syndrome in the Rat, J. A. M. A. **88**:158 (Jan. 15) 1927.

tuberal syndrome is characterized by extreme obesity and an atrophy of the genital system; neither the thyroids nor the suprarenal cortex atrophy. In certain cases the total length of these animals may be reduced; in other cases it is unaffected.

In the light of these experiments one may attribute the defect in growth to disease of the para-infundibular region, whether hypohyseal or tuberal, or both, is difficult to say. One must wait for careful post-mortem studies before a definite conclusion can be reached. That the thyroid gland also may be a factor cannot be denied; its relation to the pituitary region remains to be evaluated.

In the syndrome under consideration there are added clinical signs to indicate that the pituitary region bears a large brunt of the burden. The occurrence of increased sugar tolerance in the present case and of adiposogenital dystrophy in some of the others deserves brief comment. These observations are in keeping with the knowledge of pituitary syndromes and the results noted experimentally in hypophysectomized animals (Smith and others). The combination of pituitary dwarfism, adiposogenital dystrophy and diabetes insipidus has frequently been observed, and its relation to the pituitary region has been clearly established by experimental observations. The combination of polyuria and polydipsia with adiposogenital dystrophy, as a postencephalitic manifestation, is too well known to need further elaboration here. The occurrence of dysostosis, however, is unusual.

Dysostosis.—The involvement of the membranous bones of the skull in every case of the series reviewed is most striking and not without significance. In nine of the cases the dysostosis was confined entirely to the skull (although in one case the skull alone was studied), whereas in the rest there was additional invasion of other parts (pelvis, femur, vertebrae, scapulae and ribs). In only two cases was the sella turcica markedly impaired. As previously stated, however, the latter may not be impaired and yet the pituitary gland itself may be diseased.

The precise and striking predilection of the bony process for the membranous bones raises the question whether it can be explained on embryologic grounds.

The earliest anlage of the skull is a mass of mesenchyme which invests the anterior part of the notochord. Chondrification first takes place along the median line in what is to become the occipital and sphenoidal parts of the skull. According to McMurrich,[20] it "gradually extends forward into the ethmoidal region and to a certain extent dorsally at the sides and behind into the regions later occupied by the wings of the sphenoid and the squamous portion of the occipitals. No cartilage develops, however, in the rest of the sides or in the roof of

20. McMurrich, J. P.: The Development of the Human Body, Philadelphia, P. Blakiston's Son & Company, 1913, pp. 168-183.

the skull, but the mesenchyme of these regions becomes converted into a dense membrane of connective tissue." The cartilaginous portion of the skull, therefore, consists of the base and lower parts of the sides of the cranium; the membranous portion is made up of the roof and the region of the face.

According to Arey,[21] "it seems that the bones of the higher vertebrates that are descended from the cartilaginous skeleton of fishes pass through a reminiscent cartilaginous stage, whereas those additional bones made necessary by the increased size of the brain develop directly in membrane." In other words, the latter are more recent in the phylogenetic scale and, for that reason, perhaps more vulnerable.

In the light of the evidence that has gone before, the question arises whether the para-infundibular region is not in some measure also concerned with the trophic control of bone. Or is the dysostosis the result of osseous disease per se unrelated to the rest of the picture, except so far as the same agent which affects the tuber cinereum and its neighborhood also determines the disease of the osseous system. That is difficult to answer in the state of present knowledge. Another avenue of approach to this difficult problem has been opened by the recent investigation of Rowland,[3] in which the surprising correlation is made with xanthomatosis and disease of the reticulo-endothelial system. This brings to mind the recent clinical and pathologic studies of Pick, Bielschowsky and Sachs,[22] revealing a surprising relationship between amaurotic family idiocy, on the one hand, and the Niemann-Pick infantile type of Gaucher's disease on the other. The same disturbance in lipoid metabolism and involvement of the reticulo-endothelial system appears to be the predominant factor.

Rowland maintained that the cases herein described "represent a form of generalized visceral xanthoma-xanthomatosis in which many parts of the reticulo-endothelial system show lipoid storage or lipoid cell hyperplasia." Granted that the fundamental process is metabolic, rather than degenerative or inflammatory, how is one to account for the neuropathologic changes that occur? What is the relation between the nervous mechanism responsible for these changes and the reticulo-endothelial apparatus? Are the changes in these different systems determined independently by the same agent?

Although the mechanism for this dysostosis must for the present remain obscure, its relation to other allied conditions of the bone is of special interest.

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21. Arey, L. B.: Developmental Anatomy, Philadelphia, W. B. Saunders Company, 1926.

22. Sachs, B.: Amaurotic Family Idiocy and General Lipoid Degeneration, Arch. Neurol. & Psychiat. **21**:247 (Feb.) 1929.

On first consideration, it occurred that there might be other transitional or modified forms of the syndrome. There is a large group of cases that belong to this category: (1) the "dysostose cleidocranienne héréditaire" described by Marie and Sainton;[1] (2) "dysostose craniofaciale héréditaire," first described by Crouzon and later by Debré and Petot[2] and "dysostose cranio-faciale non héréditaire ni familial," described by Comby.[23] In this connection, the studies of Crouzon, Braun and Delafontaine[24] with reference to Paget's disease and osseous dystrophy occurring in the same family are of interest.

A study of these forms arouses the suspicion that one is dealing with different manifestations of the syndrome under consideration. A critical analysis of these conditions confirms the view that they are all closely allied to the type herein described.

In the Marie-Sainton type of dysostosis, the striking feature is the topographic limitation of the osseous dystrophy essentially to the membranous bones, not only of the skull, but also of that portion of the clavicle which is of membranous origin in contrast with the other portion which is derived from cartilage and remains unimpaired. In this connection, it is of interest to note that the appendicular skeleton represents a cartilaginous ossification with the possible exception of the clavicle, which is in part of membranous origin. The tendency to adiposity (which Marie and Sainton originally noted) and infantilism stresses further the kinship of our categorical grouping.

The craniofacial dysostosis described by Crouzon is not far removed from the previously mentioned type, as the title iself suggests. The marked exophthalmos and the bone defects limited to the skull at once bring to mind our group of cases. That this form is not necessarily hereditary or familial is supported by the case which Comby has described in a child, aged 9½, showing the characteristics of the Crouzon type.

In view of these observations, we feel certain that a revision of our knowledge and classification of the following osseous dystrophies, in addition to those already noted, is indicated: (1) osteitis fibrosa cystica; (2) osteitis deformans (Paget's disease); (3) leontiasis ossea; (4) chondrodystrophia fetalis; (5) oxycephaly; (6) osteomalacia; (7) osteogenesis imperfecta, and (8) hereditary deforming chondrodysplasia. Many of these conditions appear to be counter processes of the syndrome herein described.

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CONCLUSION

We wish to emphasize once more the high incidence of antecedent infection in the cases which form the subject of this paper. The question remains whether the syndrome of diabetes insipidus, exophthalmos and disease of the membranous bones is the result of some degenerative, toxic, inflammatory or metabolic process in which infection or trauma is the exciting factor. Particular significance attaches to the dysostosis in relation to the mechanism of diabetes insipidus.

If one reviews the pathology of the various dystrophies of the bones, it is significant that the disease has a special affinity for certain parts of the osseous system. From the evidence at hand, it seems that this selectivity is linked up with some metabolic, endocrinal or neurogenic regulatory mechanism in the anterior portion of the hypencephalon, possibly bearing some relation to the reticulo-endothelial system. The precise limitation of the bony process is strikingly reminiscent of the selectivity which occurs in the various types of progressive muscular dystrophy.

News and Comment

THE THOMAS WILLIAM SALMON MEMORIAL

The Honorable George W. Wickersham announces the establishment of the Thomas William Salmon Memorial to provide recognition for the scientist who has made the greatest contribution in the fight against mental disease during each year. Awards are to be national and international and will provide for the wider dissemination of the knowledge of mental hygiene and insanity, through cooperation with the New York Academy of Medicine, in whose hands the administration of the $100,000 fund is to be placed.

The plan provides for a series of lectures to be given in various cities of the United States under the auspices of accredited scientific, medical or educational organizations. Provision will also be made for the publication and distribution of the lectures from year to year.

The Memorial provides freedom from academic or institutional restriction of any kind and is intended to stimulate unrestrained research, study and expression of opinion.

Abstracts from Current Literature

THE DISCHARGE OF IMPULSES IN MOTOR NERVE FIBERS: IMPULSES IN SINGLE NERVE FIBERS OF THE PHRENIC NERVE. E. D. ADRIAN and D. W. BRONK, J. Physiol. **66**:81 (Sept.) 1928.

Adrian and Bronk used the phrenic nerve for investigation of the activity of the motor centers, recording the impulses in a single fiber. When a rabbit anesthetized with urethane was used, the highest root of the phrenic nerve was almost completely divided with fine needles so that only three or four fibers remained intact. The electric responses in the nerve distal to the division were examined with the capillary electrometer and valve amplifier. In five experiments the dissection of the nerve was carried to the stage at which a single series of impulses appeared in the records.

The discharge of the entire nerve was first recorded. The authors found that in quiet normal breathing, at a rate of 55 per minute, each discharge lasts about one-half second, and consists of an irregular and rapid succession of potential changes, sometimes with an indication of large excursions recurring at a frequency of about 20 or 30 a second. When forcible inspiratory movements are produced by clamping the air tubes to the trachea, each period of contraction may last a second and the rate slows down; instead of the irregular succession of potential changes there is a more or less orderly sequence of large waves at frequencies ranging from 50 to 90 a second.

The authors then studied the discharge of individual fibers. As in the case of sensory fibers, the magnitude of the responses appears to depend entirely on the local condition of the nerve. The responses do not show signs of increasing in size when the respiration is more forcible. The frequency in the discharge of a single nerve fiber varies from 20 to 30 a second during normal breathing and to from 50 to 80 a second in asphyxia. The impulses are spaced more or less evenly. A distinct pause does not occur in the discharge except that between each period of inspiration. During this pause, which lasts about one-half second, a sign of nervous activity does not appear.

Each nerve fiber transmits a series of impulses at a rate of about 70 a second, ranging, however, from 20, the rate in a submaximal contraction, to 80. It is obvious that the variations in the frequency of the discharge between the limits of 20 and 80 a second are excellently adapted for producing contractions of graded intensity without bringing fresh muscle fibers into play. The irregular character of the discharge from the whole nerve in quiet respiration shows that synchronization at the lower frequencies is not well marked and that the diaphragm, therefore, will contract smoothly although the tension in each muscle fiber will show a series of peaks and depressions.

Adrian and Bronk made a rough determination of the curve relating force of contraction to frequency of stimulation in the diaphragm of the rabbit. They found that the suction caused by the diaphragm is approximately doubled when the stimulation frequency increases from 25 to 60 a second, and that there is little further change when the rate exceeds 60 a second. Thus the frequencies which are found in a single nerve fiber cover just the range which will give the maximum variation in the force of contraction.

The authors also noted that in that part of the muscle which is supplied by the third cervical root of the phrenic nerve, a marked increase does not occur in the number of neurons in action when the contraction becomes more forcible. The gradation is due mainly to the increased number of impulses which reach the muscle from each nerve fiber. Adrian and Bronk looked for evidences of the accession of new fibers as the contraction developed by comparing the duration of the discharge of the single fiber with that of the whole nerve. In general, however, they did not find any clear evidence that the discharge of the single fiber was much shorter than that of the whole nerve.

The greatest degree of synchronization of the activity of the motor nerves occurred when the frequency was high — 60 a second — and the discharge was near its maximum intensity. The efferent nerves were all divided in the preparations and may have influenced the results somewhat. The well marked change, however, in the character of the discharge as between quiet breathing and asphyxia is fairly clear evidence that the change from asynchronous to synchronous activity takes place whether the afferent fibers are intact or not.

The authors suggest that these results are applicable to ordinary skeletal muscle, although it may be that a group of motor neurons which are activated by a center in the brain stem will give a different type of discharge from those activated in a short spinal reflex. The present investigation shows that the motor fibers of the phrenic nerve transmit discharges which are almost an exact counterpart of those in the sensory fibers. The impulses, or the action potentials, obey the same principle of all-or-nothing; their frequency varies with the intensity of the central excitation and varies over much the same range as that in the sensory fiber. The upper limit of the motor discharge in the phrenic nerve is somewhat lower than that from a sensory end-organ, but an increase to a higher rate would not be of any obvious value in the motor fiber for it would not cause any further increase in the force of contraction. The sensory discharge in a small nerve differs chiefly from the motor discharge in a few fibers of the phrenic nerve in that each sensory fiber acts independently. The impulses in the different fibers, therefore, are distributed at random, whereas in the motor fibers there is often such a degree of synchronization that the impulses occur in groups. It may be that a synchronous discharge of this kind is only encountered when a spinal center is acting under the control of the brain stem or cerebrum. If the discharge from the higher center is conveyed by a few nerve fibers to a large number of motor neurons, a group of adjacent neurons may discharge in unison because the whole group is innervated by a single fiber from above. The fact, however, that the entire phrenic nerve gives a discharge in volleys, as shown by Gasser and Newcomer in an experiment, shows that somewhere in the central nervous system, either in the respiratory center or in the phrenic nuclei in the cord, the neurons must be linked together to work in unison.

ALPERS, Philadelphia.

CONSTITUTION, PREDISPOSITION AND HEREDITY IN EPIDEMIC ENCEPHALITIS WITH SPECIAL CONSIDERATION OF CONSTITUTIONAL AND RACIAL FACTORS. ERNST PEUST, J. f. Psychol. u. Neurol. **37**:233, 1928.

The clinical material at the basis of this contribution consisted of 124 patients with epidemic encephalitis treated between 1921 and 1926 at the University Nerve Clinic in Halle. There were 68 males (among these 7 boys) and 56 females (among these 5 girls). Most of the patients belonged to the lower social strata. The occupation of most of them necessitated prolonged exposure to dust and dirt. Seventeen patients had had some nervous or mental disease prior to the onset of the encephalitis.

From the point of view of constitution the entire material is divided into four groups: 1. Patients who, in addition to having various partial disease anlages such as cranial bone anomalies, narrow flat chests, kyphoscoliosis, general muscular debility and atony, are also of a generally feeble constitution. These factors, however, seem to be only of secondary importance so far as the development of encephalitis is concerned. 2. A type of constitution which seems to favor the development of encephalitis to a greater degree than in the first group. These persons, in addition to having a marked predisposition to rickets and scrofula as well as to an anlage to the exudative diathesis, also show evidences of disturbances in physical and mental development — perhaps on an endocrine basis. 3. A group which seems to favor the development of encephalitis to a still greater extent and includes persons of the lymphatic constitution with a marked tendency to tonsillitis, angina lacunaris, grip and hypertrophied tonsils, occasionally associated with herpes labialis. 4. Patients with physical or mental infantilism and

retarded sex maturity, who seem to be most predisposed to encephalitis. In addition to these four groups the material also contains a large number of persons who show no particular constitution or type that would favor the development of encephalitis. The number of females with pathologic constitutional characters exceeds that of males by almost one-third. This is probably because so many of the former show retarded sex maturity and half of these show, in addition, psychic infantilism. The author's statistics would seem to show that retarded sex maturity, associated with infantilism on a possibly endocrinous basis, may be of significance in the pathogenesis of epidemic encephalitis.

In two cases, the encephalitis appeared at the end of the puerperium; in a third case the mother of an infant born with encephalitis gave a history of severe grip during pregnancy; the succeeding two pregnancies of this mother resulted in abortions. Another interesting case was that of a woman, aged 43, who developed encephalitis during the puerperium; at this writing the child is living but is puny and feeble; although the encephalitis in this case is progressive with increasing inhibition of motility, the mother had given birth to another child three years after the onset of the disease; this infant, however, lived only four months; it was puny and had a tendency to inguinal and scrotal hernia. Two years after the death of this child, she gave birth to a child who was well developed and is still living. The encephalitis in this case is parkinsonian in type. Prior to the illness, this woman had given birth to six normal children. Another patient developed encephalitis early in February, 1922, and had a stillbirth at seven months; the encephalitis was preceded by a stay in bed on account of rheumatism which was followed by a period during which she was somewhat confused and had headaches and high fever; this condition merged gradually into a typical epidemic encephalitis with lethargy and increasing motor inhibition. The child with the congenital encephalitis is well developed physically and has a normal personality but has difficulty of motility. It learned to run between the ages of 1½ and 2 years; since the age of 2½ it has suffered with attacks of suppuration of the middle ear every fall; speech began between the ages of 2 and 3 years, but not until tonsillectomy was performed. The father and his parents are extremely nervous and irritable persons.

In none of the 124 cases did there occur more than one case in any one family. In this connection it is interesting that Stern and Grote, who had occasion to observe 450 cases of encephalitis, found only three cases of encephalitis in more than one member of the same family.

From a geographic point of view there is nothing unusual about the occurrence of the disease. Aside from the abortive cases and the mild cases which were characterized only by changes in character and difficult social adjustment there is nothing unusual about the course of the disease. The paper is concluded with a plea for the establishment of an institution in which the patients with chronic encephalitis could be treated clinically as well as pedagogically.

KESCHNER, New York.

COMPULSIVE WEEPING AND LAUGHING. G. MINGAZZINI, Wien. klin. Wchnschr. **41**:998, 1928.

Mingazzini has been interested in the syndrome of compulsive weeping and laughing for many years, and has published several monographs on the subject. With the recent advances in studies on the lenticular and thalamic nuclei, the author has again taken up this problem. It was noted by Ball and Romberg that persons who, as a result of lesions of the brain, had developed an inability to move the facial muscles voluntarily could do so on involuntary crying or laughing. Nothnagel and Bechterew developed independent hypotheses for this syndrome, and, later, Brissaud assumed the existence in the thalamus of a coordination center for mimic movements, which functions by utilizing the two systems connecting the cortical areas with the thalamus.

Mingazzini, in his clinical and pathologic studies, has attempted to divide the group of compulsive weeping cases from the group of compulsive laughing. It

was soon noted that in cases of only moderate crying attacks the lesions were few, while patients who had exhibited marked crying attacks showed marked pathologic changes, which were frequently bilateral.

The compulsive laughing group was more difficult to study, and positive conclusions could not be drawn. It seemed fairly definite, however, that there always existed a change in the lenticular nucleus, the internal capsule and the pons. In a review of the work of Constantinis, it was found that in 65 per cent of the cases of compulsive laughing the lenticular nucleus was affected, while the internal capsule was involved in only one fifth of the cases. The author is of the opinion that the thalamus serves as a center of mimic coordination and is under the psychic control of the cortex. Pathologic study has shown that the cortical paths tend to mingle in the thalamus, and then pass through the putamen.

It has been recognized for a long time that from the corticofacial and hypoglossal centers corticobulbar fibers pass down through the knee of the capsule, descend in the pes pedunculi and pass to the bulbopontile nuclei. The facial nuclei are therefore under the influence of two afferent neural systems, the one arising in the cortex, the other in the thalamus. There is but little doubt that lesions of the lenticular nucleus produce disturbances of compulsive laughing and crying, as pathologic examination in these cases reveals definite lenticular changes. The function of the lenticular nucleus in this condition may be explained by two facts. Either the psychothalamic pathways are interrupted in the lenticular nucleus, or one assumes a lesion in the nucleus which itself produces an inhibition on the cortical fibers without directly affecting them. Angela is of the opinion that the lesions for compulsive laughing and crying need not interrupt the psychothalamic fibers, but may be situated in the rolandothalamic fibers. In spite of this work, Mingazzini is of the opinion that the corticothalamic fibers do not exert a stimulating influence on the centers of laughing and crying in the thalamus. Compulsive laughing and crying are not positive reactions, but represent negative factors.

In conclusion, Mingazzini is of the opinion that in the internal capsule or the lenticular nucleus or in both there exist essentially, in 100 per cent of cases, specific lesions which probably account for the compulsive laughing and crying.

MOERSCH, Rochester, Minn.

THE AUDITORY CENTER IN THE CHIMPANZEE. ITS MYELO-ARCHITECTONIC STRUCTURE. EDUARD BECK, J. f. Psychol. u. Neurol. **36**:325, 1928.

Beck distinguishes the following regions and subregions in the auditory area of the chimpanzee: (1) Regio temporalis insularis. (2) Regio praepyriformis. (3) Regio periamygdalaris. (4) Subregio temporopolaris; this is subdivided into: (*a*) pars medialis and (*b*) pars lateralis. (5) Subregio temporalis superior; this is subdivided into (*a*) pars medialis and (*b*) pars lateralis. (6) Subregio parainsularis. (7) Subregio temporalis transversa prima; this is subdivided as follows: (*a*) pars temporalis transversa prima intima; (*b*) pars temporalis transversa prima interna; (*c*) pars temporalis transversa prima externa; (*d*) pars temporalis transversa prima extrema, and (*e*) pars temporalis transversa prima lateralis. (8) Subregio temporalis transversa secunda; this is subdivided into: (*a*) pars medialis; (*b*) pars lateralis, and (*c*) pars caudalis. (9) Subregio temporalis transversa tertia; this is subdivided into: (*a*) pars medialis, and (*b*) pars lateralis. (10) Subregio temporoparietalis.

In the chimpanzee, as in man, the subregions as one descends caudad show a continuous increase in the myelin fiber content. The parainsular areas are poorest in myelin. The pole areas are similarly still poor in myelin. The subregio temporalis superior areas hold an intermediate position, so far as the fiber content is concerned, between the subregio temporopolaris and the subregio temporalis transversa areas. The latter, especially those in the sylvian fissure, are richest in myelin.

A comparison between these areas in man and in the chimpanzee shows no difference in the number or divisions. In the chimpanzee, however, the entorhinal

region in the allocortex does not reach so far forward as in man. All in all there is very little difference in these areas and their subdivisions in the chimpanzee as compared to man. As a matter of fact, even cyto-architectonically, Brodmann has shown that the chimpanzee's brain merely represents a small sized human brain. The author's investigations, however, convinced him that, aside from the basic plan of division of the various areas, there are still other differences of no little importance. Thus, one finds that a singulostriar type of cortex does not occur in the subregio temporopolaris. The lamina tangentialis is generally considerably poorer in myelin than in man, and the Kaes-Bechterew fibers are nowhere as prominent in the chimpanzee as in man. The singulostriar type of cortex in the areas of the subregio temporopolaris is specific for man.

Beck was unable to find in the chimpanzee as definite a difference between the right and left hemispheres as in man. Morphologically, the chimpanzee's temporal lobe stands nearest to that of man. In the former the areas of the transverse convolution, typical for the auditory center, invade for a considerable extent the second transverse convolution; otherwise, this relationship is similar to that in man; at any rate they never reach the third transverse convolution. The separation of the second transverse convolution from the third could not be made out morphologically. It could only be established architectonically.

KESCHNER, New York.

ROENTGENOLOGIC SIGNS WHICH INDICATE EXTENSION OF INFECTION FROM THE ETHMOID AND SPHENOID SINUSES TO THE BASE OF THE SKULL. G. E. PFAHLER, Arch. Otolaryng. **8**:638 (Dec.) 1928.

In 1924, Hirtz first observed that the base of the skull was involved by an extension of infection from the ethmoid and sphenoid sinuses. Normally, the lines and the cancellous structures are sharply defined; the bone is evenly and symmetrically dense. The air-containing cavities show a symmetrical transparency and a general appearance of health. "The roentgenologic signs of superficial sinusitis are a cloudiness of the affected cavity. The walls show a decreased thickening and at the same time an indistinctness or haziness in the acute stage. This indistinctness in and about the wall or at the borders is variable in extent, but in the frontal region it can be recognized at times for more than 1 cm. beyond the sinuses. At a later stage, this border on the outside of the sinus becomes denser than the surrounding bone, owing to an increase in lime deposit — the defense reaction in bone — and indicates an osteitis or perisinusitis.

"The changes incident to chronic ethmoid-sphenoid sinusitis consist of a cloudiness with a vague shading off of the anatomic details, accompanied frequently by a thickening of the posterior and lateral walls of the sphenoid and ethmoid sinuses, and associated with an area of increased density, which indicates an osteitis in the surrounding bone. This areola of dense bone corresponds in every detail to the perisinusitis in the frontal region previously described. This condition is not shown, except in association with sinusitis affecting the ethmoid or sphenoid sinuses. Therefore, Hirtz and Worms have named this condition 'perisinusite profonde.'

"This perisinusitis commonly extends into the middle fossa of the skull but it may extend into the petrous and mastoid portions of the temporal bones and even into the posterior fossa. At times, this deep perisinusitis is general and involves the base of the skull. At other times, it is confined to one side, but it always corresponds to the side in which there is a deep sinusitis. Therefore, it must be concluded that it is an extension of the inflammation directly from the affected sinus.

"As a result of an extension of this inflammatory process, one can assume indirectly an effect on the sella turcica, which may account for the anomalies which have been observed for many years, but which radiologists have been unable to explain. These changes about the sella consist of a calcification of the bridge or ligaments connecting the anterior and posterior clinoid processes, the formation of osteophytes about the posterior clinoid processes, hypertrophied tips of the

clinoid processes, calcification of bands extending from the posterior clinoid processes backward or flocculent lime deposits posterior to the clinoid processes."

Then Pfahler gives details in regard to these anomalies in the retrosellar region which may indicate local chronic meningitis, flocculent lime deposits and calcification of the pineal gland.

A report shows a case of operation on the ethmoid and sphenoid sinuses with streptococcic meningitis and death.

HUNTER, Philadelphia.

THE APPLICATION OF PSYCHOANALYSIS TO PSYCHIATRY. A. A. BRILL, J. Nerv. & Ment. Dis. **68**:561 (Dec.) 1928.

The author describes how his interest in psychoanalysis began at the same time as his interest in psychiatry at the Burghölzli in Zürich, in 1907, at a time when Freud, Bleuler and Jung were applying the psychoanalytical method. Jung had then written his "Psychology of Dementia Praecox" and freudian mechanisms were being demonstrated in the most advanced cases of dementia. In 1911, Freud developed the theory that paranoia is a defense to a homosexual wish fantasy. Bisexuality of constitution was postulated, and the homosexual was and is still explained on the basis of mother identification. The author describes one case of paranoia in which he discovers narcissistic, anal-sadistic and oral fixations. This patient identified himself with his mother and showed a poor adjustment to father substitutes. The author does not explain the resultant schizophrenia by this alone, but accepts also a certain schizoid constitution. The delusions are explained as sadistic reactions to a repressed homosexual wish fantasy.

More recent freudian formulations concerning the ego, super ego and the id are brought forth to explain the neurosis. Freud states that the neurosis represents a conflict between the ego and the id, while the psychosis is the conflict between the ego and super ego. A case is described as an illustration of this phenomenon, in which a woman fasted on the day of the execution of Ruth Snyder and Judd Gray. She identified herself with Ruth Snyder and lived through all the sordid details of the case, with evidently strong need for punishment. She was fascinated with sadistic literature, drama and murder cases. She had had phobias and obsessions since the age of 7. The mechanism of this case is explained as self punishment leading to removal of conscience and subsequent neurotic gratification of repressed wishes.

In another case, diagnosed by the author as schizoid mania, a woman, aged 54, had had attacks of depression, resistiveness, irritability and mutism for fifteen years. She showed great desire for cleaning and washing the house, as well as for alcohol. Analysis of her case showed that the attacks were celebrations and atonements for her sins, and the cleansing activity was symbolic. Spitting occurred as a purificatory rite for a previous experience of fellatio. She showed a special fixation of the libido on the oral zone, and a love disappointment before the conquest of her oedipus wishes. The repetition of early love disappointments in later life is given as a cause for the onset of her depression. Perverse kissing, alcoholism, stuttering and love for food and candy are identified by the author as oral eroticism.

The author concludes that the more recent concepts of Freud under the name of metapsychology have thrown much light on the difficult problem of the psychoses.

HART, Greenwich, Conn.

ENCEPHALOGRAPHIC STUDIES ON SCHIZOPHRENIC PATIENTS. W. JACOBI and H. WINKLER, Arch. f. Psychiat. **84**:208 (July) 1928.

The authors report their experiences with encephalography in schizophrenia, the first communication on which appeared in the *Archiv für Psychiatrie und Nervenkrankheiten*, vol. 81. In that communication the observations in nineteen cases of chronic schizophrenia were reported. In most cases, definite pathologic changes were found in the forms of internal hydrocephalus, external hydrocephalus,

narrowing of the convolutions, widening of the subarachnoid spaces, and other conditions. The authors then suggested that similar examinations should be undertaken on fresh material with the purpose of discovering whether these abnormalities were present at the beginning of the disease, or whether they developed during its course. This is the problem with which they are concerned in the present communication.

Fifteen cases were studied, all of them in young patients and most of them at the beginning of the disease (as far as could be ascertained). The technic was similar to that previously reported, but here two stereoscopic pictures were taken: (1) fronto-occipital, (2) lateral (sinistrodextral). The results found were: in most cases, a widening of the ventricular system and subarachnoid spaces; in some, a widening of single sulci. These pathologic observations, however, were much less marked than those reported in the previous communication. This makes it probable that the pathologic changes developed during the course of the schizophrenic psychosis and were not present at the onset. The authors add, however, that they have encountered cases of schizophrenia of long duration that did not show any abnormal encephalographic features. They suggest that further studies in this direction should be undertaken. If it should be proved, with larger material, that in patients with hallucinosis there is an organic change in the temporal lobes, whereas in those with more marked intellectual defects changes are discovered in the frontal lobe, one would have some additional facts concerning the mechanisms in schizophrenic processes. The material reported suggests this possibility, but is not sufficient to permit definite conclusions.

MALAMUD, Foxborough, Mass.

THE THERMOREGULATORY AND GLYCOREGULATORY FUNCTIONS OF THE STRIATE BODY. SERAFINO D'ANTONA, Riv. di neurol. **1**:97, 1928.

The author reviews the various data available in experimental and clinical medicine concerning the glycoregulation and thermoregulation of the striate body and hypothalamic vegetative centers and reports a case of hemiplegia in which the motor phenomena were accompanied by disturbances in the metabolism of sugar and regulation of the temperature of the body. The disturbance of the sugar metabolism consisted in the presence of a variable large amount of sugar in the urine, as much as 71 per thousand, and a marked glycemia which gradually disappeared on the twelfth day of the disease. The disturbance in the regulation of heat was shown by a difference in temperature between the affected and normal sides; the hemiplegic side had an average of 1 C. in excess of temperature over the normal side.

At the autopsy, two areas of softening were found: one in the posterior third of the temporal convolutions, which the author correlates with the aphasic symptoms which the patient disclosed, and one area in the external portion of the putamen of the same side.

The lesion of the putamen is responsible for the dysregulation of the sugar metabolism and temperature of the body. D'Antona emphasizes that since the putamen is only a part of the regulating chain of the two aforementioned functions, the lesions of other areas (vegetative areas of the hypothalamus and medulla oblongata) may produce the same results. On the other hand, the lesion of the putamen may not lead to a disturbed thermic or glycolytic function when other portions of the regulating chain on which the output of sugar depends are involved, or when, conversely, compensatory mechanisms will interfere. The lesion of the putamen may be followed, on the other hand, by the utmost reaction when the whole chain is in a condition of diminished efficiency.

In normal conditions, the putamen must then play an inhibitory action over the production of sugar since a destructive lesion of this area is followed by hypoglycemia. This phenomenon of release is in harmony with the views of Jackson.

FERRARO, New York.

ENCEPHALITIS RESPIRATORY SEQUELAE. H. G. WOLFF and W. G. LENNOX, J. Nerv. & Ment. Dis. **68**:337 (Oct.) 1928.

Respiratory abnormalities following encephalitis, as reported in the literature, may be grouped as follows: (1) disorders of the respiratory rate; (2) dysrhythmias, including breath holding, sighs and forced expirations, and (3) respiratory tics, such as yawning, hiccoughing, spasmodic coughing and sniffling.

Three cases are studied by the authors, with two varieties of generalized convulsive reaction besides the respiratory phenomena. In one case, the convulsion began independently of the respiratory attack. In the other there was a simple loss of consciousness with convulsive movements appearing after prolonged apnea, in which the respiratory and accessory muscles were in spasm.

Forbes, by increasing the intrathoracic pressure in cats by rapid inflation of the lungs, showed definite evidence of stasis in cerebral circulation with subsequent convulsive movements of the animal. When the intrathoracic pressure was allowed to return to normal, the cerebral circulation reestablished itself and the convulsions ceased. This helps one to understand the loss of consciousness and convulsions in these postencephalitic respiratory disturbances.

In normal persons, prolonged overventilation of the lungs will produce tetany, as shown by Collip, Bachus, Grant, Goldman and others. Blood drawn during the period of hypernea showed a decrease in plasma bicarbonate and chloride, similar to that obtained during periods of overventilation in two healthy subjects. Ingestion of from 9 to 16 Gm. of ammonium chloride reduced the plasma bicarbonate from 56 to 43 per cent by volume and it was observed that the attacks were temporarily reduced. Under an increase of plasma bicarbonate to 63 per cent by volume there was an increase in the number of attacks. Thus, the patient was better under acidosis and worse with alkalosis.

The author does not attempt to throw any light on the pathogenesis of the respiratory attacks, but believes that there is a definite relationship between the intensity of the respiratory seizures and the chemical composition of the blood.

HART, Greenwich, Conn.

LESIONS OF THE BLOOD VESSELS OF THE SPINAL CORD IN ARTERIOSCLEROTIC PATIENTS OF ADVANCED AGE. ALFONSO MAGLIULO, Riv. di patol. nerv. **33**:118, 1928.

Magliulo concludes: 1. Lesions of the blood vessels of the spinal cord in persons of advanced age suffering from arteriosclerosis are represented mainly by hyaline degeneration of the intima, and in some instances by thickening of the media with less frequently slight hyperplasia and loosening of the elastic fibers.

2. Such lesions, varying in intensity, are seen more frequently in the blood vessels of the lumbar region than in those of the cervical region and more frequently in the small blood vessels of the white substance than in those of the gray substance or of the pia meninga. Not infrequently, thickening of the small periependymal vessels is also found.

3. Although hyaline degeneration of the intima is found in the blood vessels of normal persons of advanced age, a fact which may be interpreted as a simple characteristic of senility of the spinal cord itself, this degeneration is much more pronounced in patients suffering from arteriosclerosis, and is accompanied by thickening of the media and hyperplasia and loosening of the elastic fibers; it may represent a less accentuated manifestation of arteriosclerosis of the spinal cord related to the special type of blood vessels present in the spinal cord itself.

4. The lesions of the walls of the blood vessels, either thickening of the media or degeneration of the intima, result in reduction of the lumen of the blood vessel with all the consequent nutritional changes in cells and nerve fibers. Because of the trophic changes in the nerve elements, partly due to the modification of the blood vessel and partly favored by the anatomic peculiarity of the internal blood vessels of the spinal cord, which for the most are terminal, pathologic conditions

take place and give rise to the special functional disturbances which constitute the characteristic clinical syndromes of advanced age.

FERRARO, New York.

THE SYMPTOMATOLOGY OF PROGRESSIVE PARALYSIS (KORSAKOFF'S PSYCHOSIS AND DELIRIOUS STATES). B. PFEIFFER, J. f. Psychol. u. Neurol. **37**:274, 1928.

Pfeiffer finds that Korsakoff's psychosis and delirious states are not uncommon in paresis. The former may, in some instances, be the only psychotic manifestation throughout the entire course of the disease. It need not necessarily be a transitory phenomenon. In its purer forms it is observed only in the early stages of the disease. Later on, however, it is associated with other psychotic manifestations that are foreign to the typical Korsakoff psychosis. Thus there may occur: (1) Disorientation, which is limited not only to the external world but also to the personality in the form of delusions of grandeur, and in some cases there may also appear hypochondriacal delusions. (2) Disturbances of attention and of memory for old events. (3) Confabulation, the content of which is characterized by the production of fantastic experiences and ideas of grandeur; the latter may in rare instances appear in the form of a confabulatory loquaciousness. Retrograde amnesia is rare in Korsakoff's psychosis associated with paresis. Korsakoff's psychosis may, as it regularly does in the case of alcoholism and of cerebral trauma, begin with a delirium which gradually merges into a Korsakoff picture. In most cases of Korsakoff's psychosis in paresis, especially when the latter is of long duration, delirious states are more common at night. As the disease advances, other psychoses may be superadded to the Korsakoff and to the delirious states. These may appear in the form of exogenous reaction types, such as catatonic states, acute hallucinoses as well as hallucinations and delusions of various kinds, but with no tendency to systematization. A combination with endogenous types of psychosis such as the manic-depressive syndromes is unusually rare. As the disease advances still further the cardinal mental symptom is the increasing dementia which finally overshadows the Korsakoff component of the mental picture.

KESCHNER, New York.

UNEQUAL PUPILS. E. VELTER and A. TOURNAY, Ann. d'ocul. **165**:64 (Jan.) 1928.

The authors point out that unequal pupils are frequently caused by a disturbance in the equilibrium which is produced by the delicately balanced impulses of excitation and inhibition. By different methods of examination, that is, by examination of the pupils in repose, under the action of various collyria, by provoked mydriasis and by means of pupillometry, it is possible to distinguish a certain number of clinical types.

Before making a diagnosis it is necessary to eliminate physiologic anisocoria in looking straight forward, anisocoria due to unequal illumination of the two eyes, the congenital simple type and anisocoria in lateral vision (Gianelli and Tournay). One should also eliminate anisocoria due to eye lesions, for example, iritis, irritative lesions of the cornea, contusions which produce unilateral myosis, intra-ocular hypertension, certain injuries, unilateral lesions of the optic nerve, optic atrophy and heredosyphilis of children which causes unilateral mydriasis. The unilateral mydriasis arising from lesions of the optic nerve is nothing more than an exaggeration of the pupillary inequality resulting from unequal illumination. The pupillary inequalities which have been observed in macular and perimacular lesions may be explained in the same fashion, although they are sometimes considered as a mydriasis caused by excitation of the iridodilator fibers, the chorioretinal lesion producing an irritation of the suprachoroidal plexus (Roche).

This preliminary study should be followed by a search for pupillary inequalities attributable to a disturbance of the iridoconstrictor apparatus, those caused by

disturbances of the iridodilator apparatus and pupillary inequality due to complex mechanisms which are under discussion. Included in this last classification are those types of mydriasis which are due to reflexes of indirect action; for example, pupillary disturbances in virulent tonsillitis, infection of the paranasal sinuses and periapical dental infections.

BERENS, New York.

PHOTO-ACTIVITY OF NERVE TISSUE. MAX DE CRINIS, J. f. Psychol. u. Neurol. **37**:450, 1928.

The brain of man removed from the cadaver as soon as possible after death, after being exposed to sunlight for eight hours, will cast a definite shadow on a photographic plate which had been exposed to the brain for forty hours. The same result can be obtained by substituting for natural sunlight the Kromayer lamp and artificial sunlight (quartz lamp); with this form of illumination, one and one-half hours of exposure of the brain to the light will be sufficient. There is no uniform photo-activity in the entire brain; the white substance is more photo-active than the cortex. A myelinated peripheral nerve has also a higher photo-activity than a nonmyelinated sympathetic nerve. Photo-activity of nerve tissue depends on the presence of certain substances which are soluble in ether and chloroform. These substances are the lipoids. After these have been extracted by ether and chloroform the brain loses its photo-activity. Lecithin is the most photo-active of the cerebral lipoids; it will darken a photographic plate even though not exposed to sun or to quartz light; exposure to these, however, will raise the photo-activity to an unusually high degree. Cholesterin is absolutely nonphoto-active. Fixing brain tissue in formaldehyde causes the latter to lose its photo-activity. The ability of the sun's rays to render organic substances photo-active is limited to certain seasons of the year. Experiments have shown that the photo-activity of brain tissue is diminished during the fall and winter months. Photo-activity apparently does not depend on straight line waves or corpuscular radiation, but on a special kind of active acid which is formed during processes of oxidation by the breaking down of the inactive (passive) acid molecule.

KESCHNER, New York.

NEUROTIC SUPERSTRUCTURES IN PSYCHOSES. IAN D. SUTTIE, J. Ment. Sc. **74**:660 (Oct.) 1928.

The writer directs attention away from the hospitalized paranoid patients who have reached some sort of compromise to the incipient paranoid trends in intelligent people who are being made unhappy and ineffective. He tries especially to observe a neurotic tension, which is so to speak fastened on the paranoid mechanism, and which can be treated with some success.

The patient in case *A* showed grandiose and paranoid delusions both as a boy and as a man. In the analysis it appeared that he was homosexual; by talking things out freely he became hypomanic, and then lost the delusions and the homosexuality.

The patient in case *B*, on the surface hypochondriacal, was discovered to have a paranoid system on a sexual basis. The analysis was focused on secondary neurotic symptoms and proceeded rapidly and favorably. The patient then found that the mechanisms which applied to the neurosis applied also to the psychosis. As in case *A*, an explanation of the mechanism of projection was of great help. This man became able to resume work.

The patient in case *C* was cleared of projections and egocentric suspicions, but a recurrent depression interfered by preventing him from talking.

In cases of this kind the writer has found that any discussion of the delusions is harmful until there has been a preliminary discussion of belief in general. Then by an attack on the neurotic symptoms he believes that many early paranoid cases can be cured.

BOND, Philadelphia.

THE ORIGIN OF THE COMPOUND GRANULAR CORPUSCLES IN CEREBRAL LESIONS. MARIO GOZZANO, Riv. di neurol. **1**:377, 1928.

Gozzano discusses the origin of the compound granular corpuscles in cerebral lesions and reports the data which he has collected in his experimental work on rabbits. In reviewing the literature he recalls the three views that they are derived from (1) mesodermic elements, (2) ectodermic elements and (3) both ectodermic and mesodermic elements. From his own investigations he concludes that compound granular corpuscles in the very early period of a lesion may be derived from some blood elements (large lymphocytes) belonging to the reticulo-endothelial system of Aschoff or the hemohistioblastic system of Ferrata. The transformation of adventitial cells into compound granular corpuscles is more certain, while the participation of endothelial elements is somewhat doubtful. The main source of origin of compound granular corpuscles, however, is from the microglia cells of del Rio-Hortega, which, as early as two hours after the lesion, begin to be transformed into compound granular corpuscles. The author has never been able to follow transitional forms between astrocytes or oligodendroglia cells and compound granular corpuscles. The only pathologic reaction of the oligodendroglia is the acute swelling described by Penfield and Cone. It should be remembered that a transformation of oligodendroglia into compound granular corpuscles has been admitted by Pruijs and by Belloni, and has recently been documented by the experimental work of Ferraro in collaboration with Davidoff.

Gozzano believes that the microglia may be mesodermic in nature but states that embryologic investigation alone can solve this question.

FERRARO, New York.

ALEXIA AND AMNESTIC APHASIA FOR PROPER NAMES. WALTER MISCH, J. f. Psychol. u. Neurol. **37**:223, 1928.

In a patient with pure alexia with amnestic aphasia it was striking that geographic and personal proper names could be read although few letters, and hardly any words, could be recognized. There was an especially severe amnestic aphasia for the same proper names. It would seem, then, that the personal proper name is more closely associated with the object designated by it than other names with the objects designated by them. This close association of the word image with the proper name is, according to the author, of great significance in explaining in this patient the isolated eulexia for proper names. As far as these word images are concerned the alectic behaves like a normal person. To read the proper names he needs only a few determining letters to recall the composite word image. Whereas in the case of an ordinary object the (acoustic-motor) word designating it is more closely associated with the image of the object than with the word image, it would appear that in the case of geographic and historical proper names the association of the word with the word image is still closer than that of the word with the image of the object. It would appear also that in the case of proper names the image coincides with reality. The word image of proper names mobilizes a large number of associations, whereas in amnestic reproductions the person experiences great difficulties in finding the same associations, so that these particular words are amnestically difficult but lecticlly readily reproducible.

KESCHNER, New York.

NEW RESEARCHES ON SENILE PLAQUES. G. MARINESCO, Encéphale **23**:697 (Sept.-Oct.) 1928.

The author reviews the entire series of investigations on senile plaques, beginning with those of Blocq and Marinesco in 1892 and continuing through those of Redlich (1898), Léri (1906), Alzheimer (1906), Perusini (1909), Tinel and others. Later workers have employed the newer methods of Hortega. It is with these methods that most of the advances have been made. In résumé the author concludes that senile plaques appear to be due to the precipitation of a material

of degeneration, of argentophile character, which makes its appearance as a result of a disequilibrium of the colloidal phases and exerts a chemicotoxic action on the cells of the microglia. The microglia, in the process of phagocytosis which ensues, undergoes a series of transformations which are not specific. In addition, another product of degeneration, resembling amyloid, forms the nucleus of the plaque.

The neuroglia does not take part in the formation of the plaque, so that a knowledge of the differences between the various glial types is needed to understand this study. The neuroglia, however, undergoes a process of hypertrophy of its prolongations, which envelop the plaque without invading it. The plaques are not limited to old age. Marinesco, for example, presents the case of a woman, aged 45, from his own experience. Instead they represent a specific lesion appearing when a certain alteration occurs in the colloidal equilibrium.

ANDERSON, Kansas City.

EPILEPSY CURED BY OVARIECTOMY. R. R. S. MACKINNON, Lancet **1**:910 (May 5) 1928.

This case is presented as evidence that dissociation of personality may be determined occasionally by alterations in the balance of the internal secretions. The patient suddenly developed a true epileptic condition coincidentally with, or shortly after, the establishment of menstruation. Her condition became progressively worse despite treatment and she sank into a mental state of vacancy, irritability and mental and physical deterioration. Symptoms were worse at the time of the menses; she developed enteroptosis, enlargement of the thyroid and tenderness over the right side of the abdomen. It was presumed that hypersecretion of the ovaries might be responsible for her condition and in view of the severity of the illness, partial ovariectomy was advised. At the operation the right ovary was found to be at least twice the normal size, covered with multiple cysts and congested; it was removed. The left ovary was normal except for one cyst, half the size of a pea, which was destroyed. Following the operation, the vacant expression disappeared; the patient became more alert, and in six days the goiter was gone. In the second week of convalescence, she had one attack of unconsciousness lasting four minutes, but did not have a convulsion. Four months later, she was reported as bright, alert, happy and in good physical health. She had gained 17 pounds (7.7 Kg.) and had not experienced further attacks.

PETERSEN, Montreal.

LITTLE'S DISEASE IN SISTERS AND BROTHERS AND IN TWINS. GEORG STIEFLER, J. f. Psychol. u. Neurol. **37**:362, 1928.

The paper deals with three observations on familial Little's disease. Observation 1: A sister and brother, aged 15 and 13 years respectively, were both prematurely born and showed congenital spastic paraparesis, dysarthria, strabismus and feeblemindedness. Observation 2: Three sisters, aged 13, 15 and 23 years, two of whom were prematurely born, and one of whom had delayed and difficult birth, all had congenital diplegia, cranial anomalies, speech disturbances, strabismus and imbecility; one of them also had choreo-athetotic movements. All patients thus far described showed evidences of hereditary syphilis. Observation 3: Two prematurely born twin brothers showed general congenital muscular rigidity, speech disturbances and imbecility; their mother was also an imbecile.

Stiefler emphasizes the desirability of limiting the term Little's disease to a group of cases of infantile cerebral palsies which are characterized by: abnormal birth (premature, delayed or difficult); congenital cerebral maldevelopment (regressive tendencies); paraplegia or diplegia with cerebral manifestations and muscular rigidity preponderating over the paretic phenomena. Syphilis plays an important rôle in Little's disease, especially in the familial forms. Genuine familial Little's disease is rare, but Little's disease in twins is unusually so.

KESCHNER, New York.

CONTRIBUTION TO THE KNOWLEDGE OF THE TOPOGRAPHY OF THE SUBSTANTIA NIGRA. MICHELE EMMA, Riv. di patol. nerv. **33**:677, 1928.

The author reviews the literature on the anatomy of the substantia nigra with the purpose of establishing whether, besides the zone compacta, which is generally admitted as belonging to the substantia nigra, other groups of cells possess morphologic and histochemical characteristics of the locus niger. In his investigation, Emma pays particular attention to the group of cells which has been described by Ferraro as the pars suboculomotoria of the substantia nigra and the cupuliform perirubral and retrorubral group of cells described by Foix and Nicolesco. He concludes that the pars suboculomotoria does belong to the substantia nigra as was first established in the cat, by Ferraro, though it was denied by Occhipinti and Castaldi. In addition, he also considers that the perirubral and retrorubral groups of cells also belong to the substantia nigra, which may be divided topographically into three portions: (1) the principal band or zona compacta of Sano; (2) the portion situated on each side of the medial line and reaching as high as the nuclei of the third nerve (pars suboculomotoria of Ferraro); (3) the portion located around the red nucleus (the cupuliform perirubral and retrorubral formations of Foix and Nicolesco).

FERRARO, New York.

HYSTERIA AND EXTRAPYRAMIDAL SYNDROMES. A. ROUQUIER and R. DARRE, Encéphale **23**:756 (Sept.-Oct.) 1928.

The thesis of this excellent review is that each year the diseases of the nervous system which are considered of neurotic origin, that is, without anatomic substratum, become fewer. Parkinsonism, epilepsy and spasmodic torticollis have been excluded from the "functional" group. Does it follow, therefore, that all hysterical conditions have an organic basis? This question is particularly pertinent because of the vast amount of recent work on the extrapyramidal syndromes with related emotivity. The conditions of hyperkinesis — torticollis, oculogyric crises, torsion spasm, combined faciolinguomasticatory movements, etc. — are definitely organic. Yet they can be superimposed, in a most striking manner, on tics and spasms of an undoubtedly psychogenic type. Then, too, it is admitted that most of these organic conditions can be really influenced by psychotherapy.

It is not remarkable that confusion has resulted and that some neurologists, notably Papastratigakis whom the authors discuss in detail, have ventured to deny the functional basis of any hysteria. The authors cannot concur with this view. They think that, although the condition in many cases is erroneously diagnosed as hysteria merely because so-called "organic" symptoms are absent, the old concept of Babinski still holds; namely, that hysterical conditions are produced by suggestion and may disappear with countersuggestion.

ANDERSON, Kansas City.

EFFECTS OF SPERM INJECTIONS INTO FEMALE RABBITS. W. T. POMMERENKE, Physiol. Zool. **1**:97 (Jan.) 1928.

The author's careful study of the effects of injection of extracts of spermatozoa and of control substances intravenously or intraperitoneally into the female rabbit is interesting. Summarized, his results and conclusions are: (1) The serum and the vaginal secretion of a female rabbit into which injections were made with rabbit spermatozoa or fresh testicular extract become toxic for rabbit spermatozoa. (2) The longevity of spermatozoa normally deposited in the genital tract of the female rabbit is greatly decreased by similar previous injections. (3) Infertility for a period of from six to thirty-five weeks may follow the repeated injection of spermatozoa or testicular extract into female rabbits, but not the injection of rabbit salivary gland extract or the sperm-free ejaculate from vasectomized males. (4) Injections of spermatozoa do not affect the estral cycle; but during pregnancy they may cause abortion or resorption of the fetuses. (5) The serum of a rabbit to which treatment has been given becomes toxic for rat spermatozoa, and the

serum of a rabbit immunized to rat spermatozoa becomes toxic for rabbit spermatozoa. (6) Repeated intravaginal injections of rabbit spermatozoa, by natural and artificial means, in the female rabbit may produce antigenic effects in the blood and vaginal secretions of the rabbit. However, evidence that sterility may ensue from such a procedure is inconclusive.

FERGUSON, Philadelphia.

CONTRIBUTION TO THE GENESIS OF CEREBELLAR CYSTS. A. v. SZIGETHY, Arch. f. Psychiat. **84**:715 (Sept.) 1928.

There are three types of primary cysts of the central nervous system: (1) tumor cysts which develop as a result of degeneration of a tumor; (2) developmental cysts which communicate with the ventricular system, possess an ependymal layer and show a tendency to develop at special points in the central nervous system; (3) so-called simple cysts which do not possess an ependymal layer and which are thought to bear some relationship to the development of the brain, though no such relationship has yet been established. A case is reported in which the condition was clinically diagnosed as one of tumor of the brain of unknown localization. The acute symptoms were of two months' duration and were general. The other signs and symptoms did not point to any definite localization. The postmortem examination showed the presence of a cerebellar cyst, but the histologic examination did not show any signs of tumor growth. The ependymal covering of the cyst pointed to a cyst belonging to group 2, one of the developmental type. A finer anatomic study of the connections of the growth suggested that it had developed on the basis of embryologic disturbances of the left lateral recess. The original communication with the fourth ventrical was apparently destroyed during the process of development.

MALAMUD, Foxborough, Mass.

INCIDENCE OF RHEUMATISM, CHOREA AND HEART DISEASE IN TONSILLECTOMIZED CHILDREN: A CONTROL STUDY. ALBERT D. KAISER, J. A. M. A. **89**:2239 (Dec. 31) 1927.

In attempting to control heart disease in children, one is faced with the problems of unknown etiologic factors and of the prevention of chorea, rheumatic fever and other infections which are generally assumed to be present before the heart valves are involved. As chorea alone of these is of special neurologic interest, only the results regarding that disease will be presented. Of a total of 48,000 children, 20,000 had been submitted to tonsillectomy five or more years before the present examination. Among these children, 102 had had chorea, of whom 37 had not been operated on and 65 had; 33 of the 65 had had chorea before the operation, 15 had a recurrence following the operation and 32 had the first attack following the operation. One can only conclude that chorea is as likely to occur in cases in which operation has been performed as in those in which surgical measures have not been employed. Carditis following chorea is more likely to occur, however, in the cases in which operation has been performed. The statistics show an incidence of chorea of 0.4 per cent in cases in which the patient was operated on and 0.5 per cent in cases in which the patient was not subjected to an operation.

CHAMBERS, Syracuse, N. Y.

A CLINICAL STUDY OF ENURESIS. ADRIEN BLEYER, Am. J. Dis. Child. **36**:989 (Nov.) 1928.

The author studied a group of 129 boys and 123 girls suffering with enuresis, the period of observation covering three years. Diseased tonsils and adenoids were present in 116 children; in forty-nine, operations were done for removal, with a cure of enuresis in only one case. No effect from correction of eye strain was observed. Circumcision of male children was without benefit: in thirty-three cases the boys had been circumcised, and in two instances the parents believed that circumcision had produced the disease. No relationship could be traced

between enuresis and a small urinary meatus, vaginitis, pyelitis, defective posture, malnutrition or the neurotic constitution. Sex was not a factor as the cases were about equally divided between boys and girls. The authors find a basis for the disease in "a disturbance of micturition in which the physiologic control of the brain is blocked by stronger stimuli which have to do with the nervous mechanism of the bladder." In the treatment of these patients the author used atropine in a dosage "as near the margin of overdosage (flushing, mydriasis) as is possible" and massage of the bladder through the rectum; success was met in 80 per cent of the cases.

VONDERAHE, Cincinnati.

THE PROPERTIES OF THE GONADS AS CONTROLLERS OF SOMATIC AND PSYCHICAL CHARACTERISTICS: XI. HORMONE PRODUCTION IN THE NORMAL TESTES, CRYPTORCHID TESTES AND NONLIVING TESTIS GRAFTS AS INDICATED BY THE SPERMATOZOON MOTILITY TEST. CARL R. MOORE, Biol. Bull. **55**:339 (Nov.) 1928.

This paper describes a new method for the detection of the hormone of the testes. For example, the difference between the twenty-three days' retention of the capacity for motility when both testes have been removed and that of sixty-five days when one testis has remained, has been proved to be an expression of the internal secretion of the testis (for further details of this reaction see Moore, 1928). The author presents evidence which indicates that the hormone produced by the testicles is not stored within the animal body. An experimental cryptorchid testicle of five months' duration, having a weight of approximately 0.1 Gm., produces as much hormone (indicated by the spermatozoon motility test) as do two normal testicles at the height of their spermatogenetic activity. The experimental cryptorchid testis is by weight approximately from 2.8 to 3.5 per cent that of the normal testicular mass.

COBB, Boston.

DETERMINING THE EFFECTS OF CHANGE IN TEMPERATURE UPON THE LOCOMOTOR MOVEMENTS OF FLY LARVAE. D. F. MILLER, J. Exper. Zool. **52**:293 (Jan. 5) 1929.

Much of the work of previous writers fails to show clearcut demarcation between the effects of the various factors of the environment in dealing with the behavior of insects. The effect of changes in temperature on the locomotion of the blowfly maggot was studied. An apparatus was devised to make kymographic records of the locomotion movements of maggots. It was found that the rate of locomotion varied directly as the temperature from the low limit of activity, about 2 C., to about 40 C., and inversely above this point. The rate of contraction increases directly with temperature from 0 C. to 45 C. The number of contraction waves made by a maggot in traveling a given distance is a constant between the temperatures 10 C. and about 33 C., which means that the height of contraction of the maggot is the same within this range. Above this temperature optimum and below it the height of contraction decreases. This caused the rate of locomotion to increase up to a point where the loss of height of contraction was greater than the gain from the increase of the rate of contraction.

WYMAN, Boston.

THE CIRCULAR SYNDROMES. L. REDALIE, Encéphale **23**:731 (Sept.-Oct.) 1928.

The author first comments on the greater incidence of manic-depressive cases in his private psychiatric clinic than in a large university psychiatric clinic; this situation has been commented on by others, and is one that he believes is accounted for in part by the fact that many mild cases fail to reach any physician unless the patient is of sufficient economic status. After reviewing certain views on the symptomatology of manic-depressive psychoses and outlining his own classification, he adds two other forms: circular syndromes with paranoid symptoms, and circular syndromes with catatonic symptoms. The paranoid ideas are usually not

well systematized; the catatonic manifestations occur in both phases, and when observed in the manic phase are probably to be regarded as a fleeting depression.

Eleven cases are described: four pure; three with catatonic symptoms; four with paranoid. Four patients had syphilis, but although this etiology must be considered, in one case in which the infection antedated the psychosis there was a clear cut hereditary picture of this type of disturbance. It seems more probable that the excitement of a manic attack was responsible for some of the infections.

ANDERSON, Kansas City.

RELAPSING FEVER THERAPY IN DEMENTIA PARALYTICA. K. PÖNITZ and F. SCHRAMM. J. f. Psychol. u. Neurol. **37**:282, 1928.

The authors subjected seventy-eight patients with paresis to treatment with relapsing fever. The results of this form of therapy two years after the last inoculation are summarized as follows: dead, 18 patients; not cured and confined to institutions, 15; unable to do any work but able to stay at home, 4; able to work but institutionalized, 20; fully able to work, 21.

None of the patients were subjected to after-treatment with neoarsphenamine; in view of this, the authors believe that the end-results following treatment with relapsing fever are as favorable as those following malarial therapy. Their statistics would seem to indicate also that older persons do not tolerate relapsing fever therapy as well as younger persons. Of the patients who died, the average age at the beginning of treatment was 45 years, whereas the average age of the patients in whom the disease was at least arrested was only 39 years.

KESCHNER, New York.

PTOSIS OF THE UPPER LID PRODUCED BY INJECTIONS OF ALCOHOL. G. SALVATI, Ann. d'ocul. **165**:203 (March) 1928.

Salvati states that the protection of the cornea, which is usually sought by tarsorrhaphy in neuroparalytic keratitis, keratitis due to lagophthalmos, the exophthalmos noted in hyperthyroidism and in some injuries, can be treated better by his method of injecting alcohol. He injects 1 cc. of 90 per cent alcohol containing a few drops of procaine hydrochloride into the elevator of the upper lid, close to its insertion in the upper border of the tarsus. A few minutes after the injection, ptosis develops and remains for more than one month. After this time, the lid begins to recover its normal function. If it is necessary to prolong the protection of the cornea, this may be done with a second injection. A slight edema of the upper lid is noted, with a certain degree of anesthesia, which persists for a short time without trophic disturbance. This procedure, which is more simple than tarsorrhaphy, is also more rapid and permits of the treatment and observation of the eye at all times.

BERENS, New York.

IGNORANCE CONCERNING ALCOHOLISM. CURRENT COMMENT, J. A. M. A. **91**:570 (Aug. 25) 1928.

Reliable criteria regarding the success of the present law relating to the consumption of alcoholic beverages are not available. That the very nature of this social and personal disease is yet to be determined is evident to any one after reading the discussion of the etiology of alcoholism by a group of eminent British psychiatrists (Proc. Roy. Soc. Med. **21**:54 [June] 1928). Can the craving precede indulgence or does it arise therefrom? The orthodox view is — "that it is — from first to last — a narcotic drug" (Medical Research Council). But there are distinguished opponents to this view. Neither the physician nor the sociologist can ignore the practical side of the question as to whether men drink for pleasure, to escape pain or both. Perhaps there are moral equivalents of intemperance analogous to Henry James' moral equivalents of war. War itself seems to be an equivalent, though not a moral one, to alcoholism. These unsolved problems constitute a challenge to research.

CHAMBERS, Syracuse, N. Y.

THE HEPATO-ENCEPHALITIC SYNDROME. P. GUIRAUD, Encéphale **23**:18 (April) 1928.

The case is described of a patient who at the age of 2½ years had a febrile disease of the nervous system. The result was mental arrest and parkinsonism, with death at the age of 17 from pulmonary tuberculosis. The liver was found enlarged, with a vast amount of microscopic involvement; hepatic cells were isolated; many were degenerated or filled with collagen, and the connective tissue was much proliferated. Particular attention is called to a cystic transformation of the nuclei of several of the liver cells, many attaining a diameter of three times that of the sound nuclei. Staining with hematoxylin gave an intense color. A majority contained a noncolorable spherule, a peculiar element which is described in detail.

The author adds his opinion to that of many others that Wilson's disease is not an entity isolated from pseudosclerosis and related conditions. He prefers the term "hepato-encephalitic" to "hepatolenticular."

ANDERSON, Kansas City.

CILIARY REVERSAL IN THE SEA-ANEMONE METRIDIUM. G. H. PARKER and ALISON P. MARKS, J. Exper. Zool. **52**:1 (Nov. 5) 1928.

The ciliated grooves and ridges on the lips of the sea-anemone *Metridium marginatum* remain in constant mutual relations, whether the animal is feeding or quiet, and are not subject to muscular readjustment. The cilia of the ridges in *Metridium* ordinarily beat outward; those of the grooves beat commonly inward, but both sets may be made to reverse. The cilia of a ridge removed and inspected under the microscope will continue to beat outward and may be made to reverse their stroke by being flooded with a sea-water extract of mussel meat. Inert substances, such as filter paper, are discharged from the lips of *Metridium* by the normal outward beat of the cilia on the ridges or the eventual outward beat of the groove cilia. The inward passage of food particles over the lips is often accomplished by ciliary reversal. No evidence was found of a double system of cilia, one beating constantly outward and the other constantly inward, as claimed by Elmhirst.

WYMAN, Boston.

THE SYNDROME OF THE CORPUS LUYSI. JEAN LHERMITTE, Encéphale **23**:181 (March) 1928.

Lhermitte reviews much of the fundamental work on the structure and connections of the corpus Luysi — that done by Dejerine, Jacob, the Vogts, and others. He concludes that neither embryology, anatomy nor degeneration studies clarify the functional significance of this body. He cites briefly some eight cases reported by leading neurologists which lead to the conclusion that destruction of this subthalamic body entails certain motor manifestations sufficiently particular to justify the description of a syndrome. The first and most outstanding element of the syndrome is excessive hemichorea, participated in not only by the limbs but also by the trunk. Additional elements are hemiballismus, and hemihypotonia, in contrast to the conservation of the muscular force, of sensibility and of the reflexes. Definite clinico-anatomic observations afford the basis for this syndrome rather than a speculative physiopathology.

ANDERSON, Kansas City.

CAFFEINE REDUCED COFFEES. Current Comment, J. A. M. A. **91**:886 (Sept. 22) 1928.

In December, 1927, packages of each of three so-called caffeine-reduced coffees were bought in the open market and submitted to chemical examination in the chemical laboratory of the American Medical Association. The average percentage of caffeine by weight in coffee is 1.2, and there are 1¾ grains (0.1136 Gm.) of caffeine in an ordinary cup of coffee. The amounts in the three samples were: Blanke's Refined Health Coffee, in which 90 per cent reduction was claimed,

about 1 grain (0.065 Gm.) per cup; Kaffee Hag, in which 97 per cent reduction was claimed, nearly 1 grain (0.065 Gm.); and Sanka, in which 97 per cent extraction was claimed about ½ grain (0.0324 Gm.). These facts were brought to the attention of the manufacturers, and it seems that both Kaffee Hag and Sanka contain minimal amounts of caffeine. Blanke's product is still high in caffeine; the other two are now submitted to daily checks of caffeine content.

CHAMBERS, Syracuse, N. Y.

FAMILIAL PLEONOSTEOSIS. COHEN and DE HERDT, J. de neurol. et de psychiat. **28**:395 (June) 1928.

Under the name of pleonosteosis, André Léri described, in 1921, a variety of dystrophy of the bone which followed an hereditary and familial course; it was characterized by hypertrophy, especially of the epiphysis, and, because of considerable bony development, led to ankylosis or at least to a limitation in movements. The authors describe two cases occurring in the same family. These show, besides the changes in the bone, other anomalies of the cervical region, lack of development of hair, a varus foot and some mental debility. The brother of the patient presents a small palpebral fissure, a prominent zygomatic apophysis, mongoloid features, cryptorchidism and a washed-out expression of the face. Pleonosteosis differs from achondroplasia, which is not familial and involves the bones from the intra-uterine stage of life, its evolution ending with birth. Achondroplasia involves only the radicular segments of the extremities.

FERRARO, New York.

PROGRESSIVE FACIAL HEMIATROPHY: III. REPORT OF A CASE WITH OTHER SIGNS OF DISEASE OF THE CENTRAL NERVOUS SYSTEM. H. G. WOLFF, Arch. Otolaryng. **7**:580 (June) 1928.

The case reported is one of progressive facial hemiatrophy, which on first inspection seemed to be limited to the face and was found to be diffuse. Progressive facial hemiatrophy may be associated with convulsions, scleroderma and many forms of autonomic imbalance, such as anisocoria and disturbance in growth, visceral sensation, emotions (lability and depression) and fat metabolism. These diverse lesions probably are the result of the vegetative apparatus of the brain stem. Wolff reports a case to illustrate these facts and comments that the patient presented a syndrome similar to that in the first case of this series. The association of progressive facial hemiatrophy with generalized paresthesia and tenderness of the soft parts and many signs of autonomic imbalance and depression indicated that the condition was a trophic disorder of central origin of which the facial changes were only a part.

HUNTER, Philadelphia.

MEDICOLEGAL INSTITUTES. CURRENT COMMENT, J. A. M. A. **91**:570 (Aug. 25) 1928.

As yet there is not in the United States a single establishment which corresponds to a fully equipped and organized medicolegal institute such as one finds discussed in the ninth series of "Methods and Problems of Medical Education" (Rockefeller Foundation). These institutes are departments of universities. Their main business is the study of medicolegal problems by scientific methods. It is not sufficient to call in the nearest physician or pathologist. Permanent institutions, manned by trained specialists, doing routine medicolegal examinations as well as investigative and experimental work, are the present need. Crime is progressive, and these institutions must meet unsolved problems and new situations. As physicians we have been slow in improving our medicolegal service. The most significant advance in the United States is the change from the cumbersome and archaic system of coroner to that of medical examiner.

CHAMBERS, Syracuse, N. Y.

THE EFFECT OF EMOTION ON BASAL METABOLISM. H. L. SEGAL, H. F. BINSWANGER and S. STROUSE, Arch. Int. Med. **41**:834 (June) 1928.

The effects of the thought of impending operation on basal metabolic rate, blood pressure and pulse rate were studied in three groups of cases. A constant effect on the rate of metabolism was not seen in that group which consisted of patients of various types of nervous stability with a normal rate of metabolism. In those patients with hyperthyroidism who had received iodine according to present day preoperative treatment, a marked rise in metabolic rate did not occur on the day of operation. In the group made up of persons with hyperthyroidism who had not had iodine, a marked rise in the basal metabolic rate resulted on the morning of supposed operation. A practical point is the possibility of using the foregoing procedure as an index of complete iodinization.

ANDERSON, Philadelphia.

ARTERIAL ANEURYSMS IN THE BRAIN. A. ESSER, Ztschr. f. d. ges. Neurol. u. Psychiat. **114**:208, 1928.

In ten cases of aneurysm of the cerebral vessels Esser found the anterior communicating artery involved in two cases, the anterior cerebral in three cases, two embolic aneurysms, one in the artery of the sylvian fissure, one in the vertebral artery, and one case with multiple aneurysms. Of these cases, one was an embolic aneurysm due to sepsis from a prostatic abscess, one was a case of isolated calcification of the elastic lamina, and one a case of multiple aneurysms involving the basal and meningeal vessels. Esser states that arteriosclerosis is the chief cause of cerebral aneurysm, while syphilis plays a subordinate rôle. Congenital anomalies play an important rôle in aneurysm of the anterior communicating artery. Trauma is of minor significance in the production of aneurysms and infections give rise to embolic aneurysms.

ALPERS, Philadelphia.

CONGENITAL ABSENCE OF ABDUCTION. A. WILDE, Am. J. Ophth. **11**:780 (Oct.) 1928.

The author reports the case of a girl, seen at the age of 7 years, who was unable to abduct either eye. This condition was first observed by the parents when the patient was 4 years of age. As far as could be determined, it was congenital. When the patient looked to the right, the right eye did not move any appreciable distance beyond the midline, while there was adduction of the left eye. Similarly, when she looked to the left the reverse was true: the left eye remained in the midline and the right eye was adducted. All other neurologic and ophthalmoscopic observations were reported as normal.

FERGUSON, Philadelphia.

THE ANTAGONISM BETWEEN INSULIN AND PITUITARY EXTRACT. HELMUTH ULRICH, Arch. Int. Med. **41**:875 (June) 1928.

A case of hyperpituitarism with acromegaly and glycosuria is presented, in which there is considerable evidence for the antagonistic action of the internal secretion of the posterior pituitary lobe on insulin. Huge doses of insulin were required to effect a rather limited reduction of the blood sugar. Other cases from the literature are cited to show that this is far from an infrequent occurrence, and that insulin has definitely less effectiveness against loss of carbohydrate tolerance in pituitary cases than in pancreatic diabetes.

ANDERSON, Philadelphia.

A NEW METHOD OF COMPARATIVE EXAMINATION OF THE TACTILE SENSIBILITY IN SYMMETRIC CUTANEOUS AREAS (DYSESTHESIA). F. NEGRO, J. de neurol. et de psychiat. **28**:111 (Feb.) 1928.

In order to render more accurate the comparative test for each sensibility, the author suggests painting the regions to be examined with a thin coat of

celloidin. The interposition of a thin coat of a foreign material between the skin and the stimulus seems to enhance the delicacy of sensation so that the patient is better able to determine differences in degree and intensity between the two sides of the body. The same procedure which the author proposes to call "dysesthesia" may be applied in the investigation of sensitiveness to pain and temperature.

FERRARO, New York.

NOSE DIVES FOR DEAFNESS. Current Comment, J. A. M. A. **91**:887 (Sept. 22) 1928.

Some years ago, a half dozen children, more or less, were killed in attempts to restore hearing by sudden drops in airplanes. There is, of course, nothing but folly in such a cure for organic deafness according to Lieut-Col. Levy M. Hathaway, flight surgeon; defective hearing is common among aviators, and deafness is caused and aggravated by flying. Science progresses, but human nature seems to be unchanging. A drop of 2,000 feet in a plane is preferred to syringing out impacted cerumen. A form of suggestion may cure psychologic deafness, but the airplane system will not help organic deafness.

CHAMBERS, Syracuse, N. Y.

OSTEOMYODYSTROPHY INVOLVING THE UPPER EXTREMITIES. DIVRY and LECOMTE, J. de neurol. et de psychiat. **28**:93 (Feb.) 1928.

The authors describe a case of osteomyodystrophy which they relate to the familial syndrome described by Figuena of Rio de Janeiro in 1922. This syndrome, present in a man, aged 28, is represented by a congenital dystrophy of the upper extremities involving both the bone tissue and the muscles. The bones are gracile and deformed and the muscles disclose some retractions of fibrous consistency. According to the authors, congenital syphilis may play an important rôle in the pathogenesis of the syndrome, and the process in the muscles may be of the type of syphilitic myositis. The presence of hypospadias, however, may indicate a disturbance in the morphogenesis of both muscles and bones.

FERRARO, New York.

BASAL METABOLISM. THE BASAL METABOLIC RATE IN RELATION TO SYMPTOMS AND SIGNS IN HYPERTHYROIDISM. JAMES H. SMITH, Arch. Int. Med. **41**:830 (June) 1928.

The author assigns the following values to the cardinal signs of toxic goiter: nervousness, 1; tremor, 2; loss of weight, 3; tachycardia, 4; exophthalmos, 5 and goiter, 6. By this means, a numerical index of symptoms is arrived at which can readily be represented graphically. The great majority of patients with a symptom index of 10 or less had a basal metabolic rate of less than plus 20; while almost all with an index of over 10 had a basal metabolic rate of more than plus 20.

ANDERSON, Philadelphia.

A DESCRIPTION OF THE ONTOGENETIC DEVELOPMENT OF RETINAL ACTION CURRENTS IN THE HOUSE MOUSE. CLYDE E. KEELER, EVELYN SUTCLIFFE and E. L. CHAFFEE, Proc. Nat. Acad. Sc. **14**:811 (Oct.) 1928.

The ontogeny of action-current responses was studied in the intact, unanesthetized house mouse. The age at which the first potential differences were visible was the thirteenth or fourteenth day. As the animal grew, the reaction gradually took on the adult form, although even at 21 days of age it was obviously less than that of the adult. These records show the effect of adaptation in an eye which is stimulated after short and after long exposures to darkness. The size of the reaction differs greatly, the more adapted eye giving the greater response.

COBB, Boston.

Society Transactions

BOSTON SOCIETY OF PSYCHIATRY AND NEUROLOGY

Regular Meeting, Nov. 15, 1928

H. C. Solomon, M.D., *President, in the Chair*

Personality Study of Sex Offenders. Dr. A. Warren Stearns.

A study of 100 consecutive sex offenders admitted to the Charlestown State Prison has been made. Previous studies have resulted in the recognition of three main groups of serious offenders, namely, sex offenders, murderers and thieves. In a general way, it has been found that murder in Massachusetts is largely the result of the low cultural level of certain classes of immigrants; that sex offenders are about equally divided between persons similarly of low cultural level and persons showing some degree of mental morbidity, while the thieves tend to be American born, have a higher degree of cultural development and often represent social problems of a purely local character.

Of the 100 sex offenders, 58 were convicted of statutory rape, 18 of incest, 16 of sex assaults on adults involving violence and 8 for unnatural acts of one sort or another. Violent assaults tend to be committed by young men, while other forms of sex offenses are more frequent in middle age. Alcohol was important in crimes of violence, less important in incest and of little importance in the other groups.

Fifty per cent of all groups were foreign born, the largest number being from Italy; Portugal, Poland and Canada occupied important places. The vast majority of persons committing crimes of violence were born in the United States.

A study of the cases of statutory rape showed an overwhelming number of persons of a low cultural level, from races which mature early and whose living conditions are such as to furnish unusual hazards.

A study of the incest group showed a large percentage of foreign born. Alcohol appears to have been an important factor, but most important of all appears to be the sex deprivation due to separation of man and wife for one cause or another.

In the crimes of violence, alcohol appeared especially important. The offenders in this group tended to be American born and in a general way were drawn from the group presenting the social conditions which produce the criminal class.

Definite and positive psychiatric data were relatively rare, there being a small percentage of cases of feeblemindedness and disorders of personality, and few of insanity. For the most part, persons committing these crimes in Massachusetts are drawn from the large mass of unassimilated immigrants coming from a low cultural level of foreign countries.

DISCUSSION

Dr. F. L. Wells: Dr. Stearns did not bring up the question of psychometric levels. I do not know if they are available. Murchison's data have been questioned for comparison of criminal with normal persons, but may be accepted so far as the criminal groups are concerned. In his comparison of persons convicted of different types of crime, the fraud group stands highest, and the sex groups are markedly lowest, which one might interpret as indicating that it is the person with low intelligence who does not manage these matters so as to keep clear of the law. Just as it may be easier, as Dr. Healy (?) suggests, for a camel to get through the eye of a needle than for a rich man to get into the death house at Sing Sing, so it may be unusual for an intelligent person to reach indictment for a sex offense.

Dr. Stearns: A number of years ago, when I was studying murderers, Dr. Henry M. Swift of Portland told me that I did not know anything about

murderers; all that I knew was about murderers who got caught. I think it is true that those who are caught are more primitive and simple. This is particularly true with sex offenders. It is surprising to find how tolerant families themselves are, if one excludes police and other law enforcers. The origin of the horror against incest comes from the belief that it is unnatural; yet, if one studies various animals, sheep for instance, there seems to be no natural antipathy. There does not seem to be an instinct which in any way controverts sex life between members of the same family. Our standard is an artificial one, imposed by custom.

I am confused by concepts of personality. Last fall, at a meeting of the Association of American Medical Colleges, many of the deans discussed the study of personality as a method of selecting candidates for admission. One dean interviewed all applicants; another took them to lunch. I believe that this discussion could have been made more concrete by substituting the word appearance for personality, for this is all that one can get in a brief interview. I confess, aside from the history of criminal conduct, that I cannot see that the inmates of the state prison are essentially different from the rest of us. I have talked with their wives, who say that they are good husbands, and with their employers who say that they are good workmen. Members of their own group say that they are good fellows. One is driven to one of two extremities: Either the concept of abnormal personality has been used unwisely or too freely, or else it is synonymous with the word criminal. One frequently finds that a person accused of a sex offense has shown other evidence of being a little hyperactive in this field. This should be noted as a trait, and, in my opinion, should not lead to a diagnosis implying morbidity. I think that studies along this line would be an important addition to the knowledge and understanding of criminals.

I have not determined intelligence quotients in this group. It is a rather discouraging task. For instance, in a study of about 400 negroes in the Arkansas Penitentiary, in 1915, I found practically none who had reached a mental age of 10 years. The matter of mental defect, therefore, had to be determined on other grounds. In this group at the Massachusetts State Prison, with its tremendous number of illiterate foreigners, the determination of mental age has seemed to me an unsatisfactory way of diagnosing mental defect. Furthermore, I am not convinced that an intelligence quotient in such cases determines native ability. A few years ago, I was employed in a murder trial. The prisoner was examined by an excellent psychologist and was given a mental age of 8 years. The litigation was protracted so that the man spent two or three years in jail, learning English and also learning to read and write. His teachers said that he showed unusual aptitude in his studies. Later, his mental age rated him at 13 years. Statistics do not give an accurate census of crime or criminals, just as statistics on insanity record merely the data on insane persons who have no one to care for them and so are sent to state hospitals. So it is that being in prison shows (1) that the person has committed a crime, and (2) that he has no one to look out for him.

SEXUAL PERVERSIONS IN THE LIGHT OF FREUD'S LIBIDO THEORY. DR. MARTIN W. PECK.

Dr. Peck reviewed briefly the theory of sexual development outlined by Freud in his publication of 1904, "Three Contributions to the Sexual Theory." He discussed the new points of view on the nature and etiology of sex perversions in adults which have resulted from Freud's demonstration of the pregenital sexual life of the child. Two cases of exhibitionism were presented as illustrations of some features of the subject.

CASE 1.—A married attorney, aged 35, had periods of exhibitionistic activity, associated with fugue-like states, during which he wandered from home and for days or weeks lived an indolent existence in shoddy boarding houses. There was no amnesia in these periods, but consciousness of them was dull and impersonal. The exhibitionism appeared to be one manifestation in an episode characterized by general mental regression, which apparently was allied to the states of dissociation in multiple personality.

Case 2.—In a married missionary, aged 32, exhibitionism developed during a period of sex repression when he was suddenly transferred from rural New England to the sensuous environment of the tropics. A feature of this case was the uncontrollable intensity of the impulse. For long periods there was no tendency to exhibit, and the man was supremely confident of his self control. When opportunity and impulse came together, however, he was swept along, with no capacity for volitional inhibition. Under analytic psychotherapy, power of control gradually developed, although the impulse occasionally recurred. For a period of three years, during which this patient could be followed, there was no reappearance of overt activity.

Dr. Peck's main purpose was to give an elementary presentation of sexual perversions as explained by the libido theory and set forth by Freud in his "Three Contributions to the Sexual Theory," published in 1904. He felt that many persons might not be familiar with this literature, and that the intricacies of later developments had been intentionally avoided. His remarks on masturbation were concerned chiefly with the practice in the adult, while infantile masturbation, assumed by Freud, is a universal phenomenon. He mentioned a recent widespread questioning of mothers in a baby health week in a midwestern city which tended to bear out Freud's hypothesis.

Why We Have Traits: The Theory of Integration of Dispositions. Dr. Morton Prince.

I wish to point out the importance of the problem of personality in the understanding of human behavior, both of individuals and of groups (communities, races and nations). Such an understanding must include, besides the individual traits of which personality is composed, the motivations which are the springs of action and which determine behavior. But what are traits? From a descriptive point of view, by traits are meant: the sentiments and ideals with their meanings for the individual; the more complex habits; the fixed acquired beliefs and prejudices, and likes and dislikes; the accepted ethical and social codes of conduct; the aspirations and enduring desires; the innate cravings, urges or impulsions, appetites and inherited tendencies in general, all of which, according to their varying combinations, distinguish one individual from another and determine behavior. (Concrete examples were presented from the characters of historic personages, Bismarck, Lincoln and Disraeli.)

In the pathologic field, phobias, impulsions and other obsessions are traits of personality. They are pathologic simply because they prevent proper adaptation to the situations of everyday life. Likewise, criminal and delinquent behavior and tendencies are traits. Traits of personality are the springs of action or the principal motivating forces that determine the logical and other intellectual processes of thought.

A psychologic definition of traits in terms of behavior is too narrow. An adequate definition should be in terms of mental processes that determine behavior rather than of the resultant behavior. From this point of view, a trait may be defined as an habitual mental reaction of the individual to an actual or ideal situation. This definition would include and give full weight to repressed, subconscious desires, aversions, apprehensions, etc.

One characteristic of traits is that they are obstinately persistent and enduring; otherwise, they would not be habitual or characteristic of the individual. This does not mean that they cannot be modified or eliminated in accordance with new experiences and replaced by others of even an opposite character with corresponding changes in the personality. A second fundamental characteristic of traits is that most of them are acquired.

Why do traits endure? And why do we have them at all? The most satisfactory theory is that of "Integration of Dispositions." According to this theory, traits depend on the organization of inherited and acquired psychophysiologic dispositions. That is to say, they are the functioning of organized integrates of such dispositions.

Dispositions? What are they? Inherited dispositions admittedly are tendencies of preformed physiologic arrangements of the nervous system. Acquired dispositions must be tendencies of conserved experience; but one cannot conceive of experience being conserved in any way except as physiologic records. This is the theory of memory. In the last analysis, then, acquired dispositions are physiologic and are created, organized or integrated by experience. They may be called "neurograms."

If this is so, personality is as much a structure as the brain and spinal cord are. But the important thing is that the structure of the latter is innate and inherited while that of personality is only in part inherited as primitive, instinctive dispositions, and for the most part is acquired through experience. Personality, then, may be considered as a composite structure built by experience on a foundation of preformed, inherited, psychophysiologic mechanisms (instincts, etc.).

But how can the mechanism, whether of a chick or of a human being, "acquire" experience? Every biologist accepts the theory that what is acquired forms "dispositions," that an experience tends to leave in the nervous organization dispositions which become integrated with the instinctive dispositions and that it thus forms a functioning whole with respect to specific situations. The instinctive impulses are accordingly modified by the acquired dispositions. By experience, new dispositions are deposited (that is, "acquired"), organized and systematized, not only among themselves but integrated with inherited mechanisms. Thus are formed new structural mechanisms which in their functioning manifest themselves as those mental processes which one calls traits. Accordingly, one may say, as a final analysis of traits: Personality is the sum total of all the biologic innate dispositions of the individual and of all the acquired dispositions and tendencies acquired by experience, and it is limited to these. The former would embrace the emotions, feelings, habits and other tendencies manifested in instinctive reactions to the environment; the latter, the memories, ideas, sentiments, habits and other complexes of intellectual and affective dispositions, acquired and organized within the personality by the experiences of life. But all are integrated into one functioning organism or whole. Acquired dispositions are organized into complexes, many of which become traits that characterize the individual and determine his reasoning processes, his feelings and his attitudes, in short, his reactions and his behavior in specific situations. For they not only have an organized structure, but possess a dynamic potentiality and drive, largely due to the fact that within the complexes are incorporated one or more emotional or other instinctive mechanisms from which most, but not all, of their energy is derived.

The important corollary of this theory of dispositions is that one should not look for the springs of human behavior in a single vital principle, such as the urge of a libido, or an élan vital or other metaphysical entity, but rather in the motivating energy derived from and inherent in the different inherited, instinctive dispositions and the many multiform, integrated and organized systems of acquired dispositions created by experience.

The common popular aphorism that human nature cannot be changed is erroneous. Personality can be changed by modifying and reconstructing traits and by organizing new ones through the creative force of new experiences. This I have done time and again as it has been done by others.

From this theory of personality, it is obvious why human beings have traits, why traits are so obstinately persistent and why they cannot be changed at will but can be changed by educational, therapeutic and other procedures (that is, by experience). But as traits have wide, ramifying roots and settings in dispositions left by experiences of the distant past, often reaching back to childhood and conserved, perhaps as cravings, in the unconscious beyond the reach of awareness, the new modifying experiences, whether educational, therapeutic or those of everyday life, in order to be effective, must create new roots and settings that will construct new meanings, new points of view, new habits and new attitudes, and provide new cravings and drives. Such modifications result in new brain patterns, new structures, which mean new traits or the elimination of old ones.

NEW YORK NEUROLOGICAL SOCIETY

Regular Meeting, Dec. 4, 1928

S. P. GOODHART, M.D., *Councillor, in the Chair*

MULTIPLE SCLEROSIS: OTITIS MEDIA PURULENTA CHRONICA. DR. MICHAEL VINCIGUERRA.

Clinical History.—L. G., an Italian laborer, was first seen by me at the Post-Graduate Hospital Clinic on Nov. 14, 1928. His chief complaints were dizziness and a sensation of numbness and weakness in the right upper and lower extremities. He gave a history of recurrent attacks of dizziness and visual disturbances, beginning in June, 1927, and rendering him unable to work. The attacks were not accompanied by unconsciousness, nausea or vomiting. Diplopia had persisted for three months.

Examination.—Physical examination of all of the organs gave negative results, except for poor condition of the teeth. All laboratory tests were negative except that roentgen examination showed an old left mastoiditis. Neurologic examination showed that the left pupil was slightly irregular and the left palpebral fissure smaller than the right. A fine nystagmus was present in all directions in extreme gaze, also slight adiadokokinesis on the left, diminished abdominal reflexes, some spasticity and incoordination of the right lower extremity.

Diagnosis.—The multiplicity of lesions, the nystagmic movements of the eye, the absence of abdominal reflexes and the incoordination of the right lower extremity, would seem to indicate a diagnosis of multiple sclerosis.

Comment.—The ear examination by Dr. Marvin F. Jones on Nov. 16, 1928, showed: otitis media, chronic, purulent, bilateral. Functional test revealed: low tone limit right 128, left 64; high tone limit right 0.3, left 0.2; Weber test not referred; bone conduction increased in both ears.

Nasal examination showed some deflection of the nasal septum to the left with a ridge along the floor.

Throat examination showed bilateral diseased tonsils, fibrous and cryptic, with slight, glandular enlargement.

Examination of the eyes revealed: spontaneous horizontal nystagmus to the right; approximation of the quick and slow component, but not of a true oscillatory type. Spontaneous nystagmus was present to the left irregularly and transiently. Spontaneous vertical nystagmus was present when the patient looked up, but not present when he looked down. There was spontaneous past pointing to the right with the left arm, but no past pointing with the right.

Bárány Tests: After twenty-five seconds of irrigation of the left ear with water at 68 F., nystagmus appeared when the patient looked directly ahead (spontaneous nystagmus not noted in this position). The irrigation increased the existing nystagmus and changed it from a horizontal to a rapid rotatory type. There was no past pointing with the right hand, but past pointing to the right with the left hand was produced. With the head posterior, the horizontal canals were also found to be functioning.

Twenty-five seconds of irrigation of the right ear with water at 68 F. produced a nystagmus with the patient looking directly ahead. Nystagmus in all other directions was increased, and the character changed from a horizontal to a rotatory type. There was no past pointing with the right hand except once. The left hand still past pointed to the right.

When the patient stood on the floor following the irrigation, there was an unsteadiness but no definite falling.

The duration of the nystagmus could not be timed as it was spontaneous.

The patient had had trouble with the ears since he was 17 years old. He thinks that he got water in them and that that started them running. The discharge was thick or thin and was unaccompanied by pain. About seven years ago, there was a foul smelling, intermittent, thick purulent discharge which would

occasionally stop. The onset was entirely without pain, and he has had no pain since. During treatment of the ear by irrigation he was occasionally made dizzy, but not sufficiently to fall from the chair. Lukewarm water was used for irrigation. The discharge from the ear had no relation at any time to dizzy attacks. He has been advised on two occasions to have an operation performed on the ears, once at the New York Eye and Ear Infirmary and once at Fordham Hospital. He had x-ray pictures taken at Fordham Hospital and at the Italian Hospital. It was after seeing the pictures at Fordham Hospital that he was advised to have an operation. The patient has never had any fever since this trouble originated.

Course.—On November 23, the left ear was discharging; it was filled with soft granulation tissue. Almost a central nystagmus was present. There was a very slight transient nystagmus; spontaneous nystagmus in all directions. It was necessary to superimpose a stimulus to bring on central nystagmus.

Irrigation of the left ear with water at 68 F. caused central nystagmus after twenty-five seconds, and the true horizontal type of spontaneous nystagmus was changed to a rotatory type of horizontal nystagmus. With the head posterior the same change was noticed. There was no past pointing with the left hand; past pointing occurred to the left with the right hand. When standing erect on a wide base, he was dizzy but did not fall. A tendency to fall to the left with the feet together was present.

The duration of nystagmus was 2+ minutes. There was a rather severe sympathetic reaction with pallor of the face and a sensation of dizziness.

DISCUSSION

DR. MARVIN F. JONES: The interpretation of the observations is that there is stimulation passing through the inner ear as noted by the nystagmus. The nystagmus was normal following the irrigation, but there was no stimulation reaching the reflexes, denoted by the past pointing, also by the standing. He had an unsteadiness, but no falling. I would deduce from these observations that the lesion is not one of the inner ear.

DR. MICHAEL OSNATO: I wish to thank Dr. Jones for the great amount of work he has done in connection with the Neurologic Department at the Post-Graduate Hospital in attempting to study and clear up these difficult situations; it is in this type of case that the neurologist and neuro-otologist can work together in order to get definite data concerning the clinical meaning and the anatomic correlations of nystagmus and disturbances of the vestibular reactions. The case illustrates the teamwork that is possible between the different specialists interested in various parts of the nervous system. When this man was presented at the staff conference he was presented with the diagnosis of a cerebellar abscess. Two things stood out as the result of the presentation. One was the great variability of the symptoms. Reliable men reported different data at various examinations. The second striking feature was the multiplicity of signs; they could not be explained on the basis of one lesion, and the neurologic staff was almost unanimous in the opinion that this was not a chronic cerebellar abscess or any type of single lesion of the brain. Because the man could not speak English it was hard to obtain the history, but there appeared to be a history of apoplectiform attacks, and it was considered that possibly several vascular insults might have accounted for the symptomatology. The third diagnosis, which I believe is the correct one, was that he was suffering from a multiple sclerosis, and I think that is the diagnosis which Dr. Vinciguerra advances.

DR. S. P. GOODHART: What was the first symptom?

DR. VINCIGUERRA: Dizziness, followed by blurred vision; after this he felt that his eyes were moving in a horizontal plane.

DR. J. H. HUDDLESON: I think attention might be called to one other symptom: the gait was not mentioned, but suggests a parkinsonian postencephalitic picture; the way the head is held, the slight forward bending of the body, and also the fact that he does not swing the arms as much as he normally should. At the same time I feel that the diagnosis of multiple sclerosis is correct.

A Case of Parkinsonism with Bulbar Signs of Undetermined Etiology. Dr. Rubin A. Gerber.

As this patient walked in, he held himself somewhat rigidly and did not seem to have the normal associated movement of the left arm. His chief complaint and symptoms were those connected with his speech. He had difficulty in pronouncing words and in speaking; also, he had had some difficulty in chewing, but no trouble in swallowing. The condition began about a year ago when friends told him that he did not talk clearly. He attributed the condition to the extraction of a tooth, which preceded by about two weeks this difficulty in speech. He had a great deal of pain from the extraction of the tooth. The patient was a man, aged 32, and had been a stammerer ever since he was 9 or 10 years of age; the stammering had appeared and disappeared at times. Previous to the onset of the present difficulty he had had no stammering or speech difficulty for two years. He was a traveling salesman and had been doing exceedingly well.

He did not show any disturbances of the pyramidal tract. His reflexes and sensorium were all normal. There was not the normal rigidity one would expect in a case of Parkinson's disease. He had no cogwheel resistance. At the onset he had a marked tremor and used to blush occasionally, but since lumbar puncture and a little treatment he has improved and is not so nervous. The abdominal reflexes were present, but slightly diminished. They were not exhaustible.

Examination of the cranial nerves resulted in the demonstration of certain disturbances: There were no changes in the ocular apparatus. The pupillary reflexes were normal. There were no disturbances in the eye muscles. The right nasolabial fold showed a little more contraction than the left. In talking, the upper lip did not seem to move very much. He had a marked tremor of the tongue. I do not believe there was any actual atrophy, but the tremor was marked; in fact, it was a fibrillating tongue. The vocal cords were normal. The palatal and pharyngeal reflexes were also normal.

Laboratory tests gave negative results.

The etiology is the question which interests me. It is granted that he has a parkinsonism. Also, I contend that he has some signs of slight bulbar involvement referred to the twelfth cranial nerve and only very slightly to the seventh nerve. He has perfectly normal masseter muscles. He has only one additional feature: a blood pressure of 150 systolic and 110 diastolic, but no arteriosclerosis of the retinal or other vessels can be demonstrated. The blood chemistry is normal. Mentally he is competent. There is no question of syphilis; the Wassermann tests with the spinal fluid and blood are negative.

Summary.—The case is presented as one of parkinsonism and slight bulbar signs with an undetermined etiology. I do not think it is fair to say it is postencephalitic. There are some things to be said in favor of encephalitis; the fact that the lesion is disseminated and has extended over a large area, and the fact that one usually associates parkinsonism with encephalitis. But there are a number of things to be said against it: the lack of history, the lack of the usual sequelae, and the lack of evidence in the spinal fluid. Finally, there is no reason why one should say it is postencephalitis of the epidemic type. I think it is fair to call this case one of parkinsonism with bulbar symptoms of undetermined etiology.

DISCUSSION

Dr. Moses Keschner: I agree with Dr. Gerber in the diagnosis and the localization of the lesion, except that I should be more inclined to view it as a case of bulbar involvement with little parkinsonism. Except for the tremor, which I understand is not parkinsonian in type, he shows little disturbance of the finer associated movements of the hands and fingers. He does not swing his left arm as well as he might. Aside from this, he did not impress me as a patient with parkinsonism. In view of the fact that there is no clearcut history of encephalitis, the possibility of a degenerative disease must be seriously considered.

In view of the fact that the patient has always been a stammerer and without evidences of or reasons for cardiorenal involvement, he has a hypertension at a comparatively early age; I should like to ask if Dr. Gerber would not consider the possibility of a degenerative lesion which has involved the basal ganglia to some extent and to a greater extent the lower part of the medulla.

DR. MICHAEL OSNATO: Dr. Keschner's observations are those made in staff conference when this man was presented; exactly his thought occurred to me. The death of a patient with an acute bulbar encephalitis the other day, fifteen minutes after I saw him on the ward, when he had been in the institution only thirty-six hours, brings to my mind my personal experience with patients with encephalitis that begin with bulbar symptoms. They are usually very ill. I do not recall ever seeing a patient with an acute case of encephalitis with bulbar symptoms who was not extremely ill. We have all seen patients with bulbar residuals later, but the patients who have bulbar symptoms at the onset are very ill indeed. I cannot conceive that this man has suffered from the beginning with bulbar symptoms as part of an acute encephalitis and has walked around comfortably, never having been sick enough to stay in bed one hour. In my experience, this type of onset does not allow this case to be fitted in with acute cases of encephalitis beginning with bulbar symptoms. That is my chief reason for believing it is a primary bulbar palsy.

In regard to these primary degenerative bulbar processes the more one sees of them and follows them up, the more apt they are to turn out to be amyotrophic lateral sclerosis. I incline to the theory that this case is a primary degenerative bulbar palsy.

DR. ALEC RABINOVITCH: The evidence of involvement of the cranial nerve which this patient has could be ascribed to bulbar or to pseudobulbar involvement, but one must take into consideration that a good many of these cases do not show any involvement of the pyramidal tract and on a pseudobulbar basis one finds evidence of cranial nerve disturbance purely in striatal disease. You all have seen fairly commonly older persons in almshouses who have difficulty in walking and yet no evidence of pyramidal disease; they have definite bulbar involvement and bulbar symptoms, such as difficulty in swallowing, difficulty in speech, all purely on a striatal basis. I cannot see why, in this particular case, assuming that this patient does show striatal involvement, it is possible that whatever bulbar symptoms the patient does show are not due to involvement of the pyramidal tracts, but purely on the basis of extrapyramidal disease. The fact that this patient gives no previous history which would point toward an encephalitis does not offer any obstruction. I think that this case is postencephalitic, and at the same time whatever bulbar evidence is shown is due to a result of striatal and not pyramidal involvement.

DR. RUSSELL MACROBERT: Dr. Gerber has presented an interesting problem. This man's manner of speech is so unusual that it is worth some thought. As he talks here it is easy to detect a distinct stammer as well as a slurring element. Altogether the speech does not correspond to any of the three organic types of speech, the spastic dysarthria of a cerebral lesion, the atrophic dysarthria of bulbar disease or the ataxic dysarthria of cerebellar disease.

I was not deeply impressed with the evidence offered to support a cerebral location for the lesion similar to that in Parkinson's disease. There are: no trace of propulsion in gait, none of the usual spasticity of the face muscles and no abolition of reflex eyelid blinking. The suggestion of bulbar or atrophic dysarthria is likewise not impressive in view of the absence of bulbar paralysis. I admit a tremor of the tongue, but it is protruded well, and there is no atrophy or fibrillation in the muscle such as occurs in nuclear degeneration. The patient also moved his lips well on request.

This man is reported to have been a stammerer, in fact to be one of a family of stammerers. He attributes the onset of his trouble to an injury in tooth pulling which is obviously an impossible cause of organic brain disease. I do not claim that he is suffering from frank hysteria, but to my mind, with the dearth

of evidence for organic disease and the speech defect fitting into no organic category, I make the suggestion that the trouble is a functional one in a neurotic person.

DR. GERBER: It is difficult to answer the gentlemen who have spoken. I suppose that if the case had been presented as one of postencephalitic parkinsonism with some bulbar signs there would have been no discussion at all. I have noticed that some have maintained that this case shows marked evidence of parkinsonism with slight bulbar involvement, while others have spoken of the marked bulbar symptoms with slight parkinsonism. That makes for confusion both in discussion and in nomenclature. I wish the chairman would speak a little about how much is known of striatal syndromes and various other pathologic conditions associated with motility and rigidity.

To answer Dr. Keschner's question, his suggestion has been considered, as Dr. Osnato has mentioned, but I do not believe that the observations are largely bulbar as he believes; this is not the type of "hot potato" speech one expects in bulbar cases. I do believe that the evidence of parkinsonism is definite and fairly well marked. Style seems to have changed in encephalitis; one does not see so many patients with the marked tremor and marked postural rigidities that one used to see several years ago.

I am grateful for Dr. Osnato's remark. It bears out my experience about bulbar cases. I have seen very few of these patients who have survived. The patients with bulbar involvement and encephalitis seldom lives long, and this particular case seems to have been stationary for the last few months.

I cannot quite understand Dr. Rabinovitch's remark. I made no mention of pyramidal involvement; there is no question of pyramidal tract disease and no question of this being a bulbar case or a pseudobulbar case. It is simply a case with some slight bulbar symptoms. I do not know whether this condition might not be limited purely to the substantia nigra, perhaps to the globus pallidus, or perhaps it is a disease of the palliopontocerebellar fibers.

Dr. MacRobert's discussion interested me very much. A capable neurologist made a similar diagnosis when an almost similar case was presented at the Vanderbilt Clinic several weeks ago. To me the suggestion of its being functional is untenable. I think the evidence of actual organic involvement is so marked that the functional explanation can be excluded definitely. There is no question that many patients with encephalitis and parkinsonism show a more marked tremor and nervousness, such as this patient showed at the beginning of his illness, and which has been ameliorated by treatment. That this man is neurotic is admitted.

BULLET WOUND OF THE BRAIN WITH INVOLVEMENT OF THE CRANIAL NERVES. (LANTERN SLIDE ILLUSTRATIONS.) DR. GEORGE A. BLAKESLEE.

R. J., a man, aged 19, single, a negro, was admitted to the Harlem Hospital at 7.30 p. m. on Nov. 21, 1926. When first seen by the ambulance surgeon in a room in an apartment he was lying on his back in a state of unconsciousness. He was immediately removed to Harlem Hospital, where a physical examination revealed extensive contusions with marked discoloration about the right eye. The right upper and lower eyelids were swollen and widely separated by a protrusion of the eyeball. The eyeball was severely lacerated and almost completely enucleated. The left eyeball was in normal position, the pupil being about 4 mm. in diameter; it reacted promptly to light. A serosanguineous fluid was flowing from the nostrils. The patient was unconscious; frequently during the examination he became very restless, throwing himself about the bed and talking incoherently. During the day, much dark red blood was vomited. There was urinary incontinence.

A spinal puncture was performed on the day of admission, and a uniformly bloody fluid flowed in all three tubes. Later, on the same day, the patient became more comatose. Dr. Schiller of the Eye Department reported a small lacerated wound in the nasal side of the right upper eyelid. The eyeball was collapsed and protruded between widely separated eyelids. The cornea was divided by a

lacerated wound and the anterior chamber obliterated. The vitreous fluid had escaped. Enucleation of the injured eye was advised.

A neurologic examination revealed a patient, restless, unconscious, and held in bed under restraint. He was able to move both upper extremities with no limitation of movement. He was able to raise the right lower extremity, but it quickly fell back on the bed. The movement in the left lower extremity was limited, and he was not able to sustain its position when it was lifted from the bed. There were no abnormal involuntary movements.

The cranial nerves showed a trauma of the right side as already described. The pupil of the left eye was 2 mm. in diameter, regular in outline, and reacted promptly to light. There was a complete facial paralysis on the right side.

The reflex examination showed the biceps, triceps and patellars present, but barely elicited. The achilles reflex on the left side was present, but greatly diminished, and that on the right side was absent.

Sensory examination was impossible because of the mental state of the patient.

Course.—The right eyeball was enucleated on the fourth day of the illness. The patient regained consciousness on the ninth day when a second neurologic examination revealed: no paralysis of the arms or legs, though the muscle strength was less in the right arm and leg than in the left arm and leg; no abnormal involuntary movements; the left pupil 4 mm. in diameter, regular in outline, and reacting to light and convergence; complete right facial paralysis and loss of hearing in the right ear. In the distribution of the right trigeminal nerve, pain sense was lost; temperature sense to hot and cold was greatly diminished but not entirely lost. Tactile sense was diminished. The deep reflexes were still generally diminished with the exception of the right achilles reflex, which was lost. The abdominal reflexes were active and equal, and there was a bilateral plantar reflex. The general sensory condition was normal, with the exception of the right trigeminal distribution. There was still urinary incontinence. The temperature was usually normal with a pulse rate between 70 and 80. At one time the temperature reached 102 F. but it dropped to normal in three days. Just before death, the temperature reached 106 F.

Roentgen examinations were made frequently in the first twenty-four hours after the patient's admission to the hospital; others were made at two and three day intervals.

The patient died on Dec. 19, 1926, two days after the operation, after having been in the hospital twenty-six days.

Anatomic Diagnosis.—There was a bullet wound of the right orbit, of the greater wing of the sphenoid, of the right temporal lobe and of the inferior peduncle of the cerebellum; subarachnoid hemorrhage; operative wound at the back of the neck; laminectomy; pleuritic adhesions on the right; operative incision in the left side of the chest; scars on the forehead; terminal bronchopneumonia.

Description of lantern slides: The first x-ray picture showed the bullet with its nose downward, and its base upward. It was located in the lower portion of the posterior fossa. A few days later the nose of the bullet pointed upward toward the vertex, and the base of the bullet was down. Then an anteroposterior view was taken and the bullet pointed toward the left with the base toward the right; it was almost in the midline, but slightly toward the right. Eight days after admission, the bullet had gone very much more posteriorly in the posterior fossa, and the nose of the bullet was pointed directly toward the occiput. Again, it was resting near the base of the brain in the posterior fossa. The last picture showed the bullet down in the cervical region, opposite the atlas, with its nose pointing down and its base upward.

DISCUSSION

DR. MICHAEL OSNATO: The striking features to me are the possibilities of speculation in explaining the diminished reflexes, particularly the absent achilles reflex on the right. In the absence of other explanations, one is forced to speculate

on what possible influence the inferior cerebellar peduncle may have had in determining these symptoms. I have had no knowledge of this case before tonight. Possibly the explanation may be found in those fibers, of considerable number (small in comparison to the total which go from the nuclei of Goll and Burdach), which go through the fillet and to the thalamus, which, however, finally become a part of the inferior cerebellar peduncle; in that way an analogy might be drawn between the explanation of the diminished reflexes in tabes and the diminished reflexes in this case. I cannot see any other reason for the diminished reflexes in the absence of evidence of a peripheral neuritis or other lower motor neuron involvement affecting the extremity.

HYPOTHESIS OF THE MECHANISM OF VERTIGO. DR. RANDAL HOYT.

Vertigo being a conscious reaction, its locus is in the cerebral cortex. It consists of a nondiscriminative and a discriminative component. The former is the basic kinesthetic sense, and is produced by the predominance of vestibulocerebellar over pallial energy. The latter is a proprioceptive interpretation, mechanically similar to stereognosis. If a man flexes the forearm the state of consciousness produced is not referred to the muscles, joints and tendons, but to the forearm as a whole moving through space; if he flexes the arm while holding a heavy weight in the hand, consciousness is then referred to that experience. These differential interpretations are possible because the relative expenditure of energy of the muscles, joints and tendons — and their accompanying nerve stimuli — is different in, and specific for, each motor experience. Again, if a person standing in the upright position leans to the left, he automatically abducts the right upper and lower extremities; if he stands with his left side in close approximation with a wall — so that he cannot lean to the left — he cannot abduct his right lower extremity. Thus the association between these right abductive movements and the act of leaning to the left is fixed and absolute. After rotation to the right through the frontal plane of the head, right abductive movements are spontaneously induced, and are interpreted consciously in terms of their usual accompanying experience, namely, that of leaning or falling to the left.

If at the time of this interpretation, vestibulocerebellar energy predominates over that of the pallium — i. e., if there is a coincident state of kinesthesia — vertigo is then produced.

DISCUSSION

PROF. FRANK HENRY PIKE: Some years ago a friend and I became interested in the question of the function of the internal ear, and we thought that we would like to analyze the mechanism of nystagmus. The mechanism appeared so complex that I gave it up for the time being and started on the analysis of another mechanism. So, tonight, I am very much in the position of the student of history who was asked a question on the age of Pericles in Greece; he found he did not know much about that, but he could tell a lot about the Punic Wars. There is so much confusion and so much looseness of terms in everything dealing with the internal ear at present that I freely confess that I have no clearcut idea of the mechanism of nystagmus. I tried the analysis of a mechanism which I thought would be simpler, following a suggestion of Hughlings Jackson, and started on the analysis of the neuromuscular mechanism of respiration. After working at that for some years, I think I can see how that mechanism is put together and how it operates, but I cannot yet see how the mechanism of nystagmus and vertigo works. It is probably a more complex mechanism than the other, and it has probably undergone a number of changes in phylogenetic development. There are, however, one or two things of which I might speak.

I noticed that Dr. Hoyt is not so insistent as some are on the cerebellar contingents of the vestibular fibers. I do not see yet just why the idea that the great central course of the vestibular fibers passes through the cerebellum got into the literature, nor why it has remained so long. If one goes back, one finds at the time of Flourens and his experiments on the internal ear, about 100 years ago,

that those who saw his animals or read descriptions of their deportment, but did not see his experiments, insisted that he had injured the cerebellum. It was not until about 1891 that it was shown to the satisfaction of people generally that one could get typical vestibular reactions without any injury whatsoever to the cerebellum. From my point of view, working largely with animals, one notices certain defects when the vestibular system is gone. The cat, noted for its agility, cannot jump from a moderate height — a table 30 inches high — without coming down in a heap and bumping its chin when it strikes the floor. It soon learns that it cannot jump, and usually does not try more than once or twice. It is a little unfair to ask a cat to swim, so we tried that on a dog. A dog with both vestibules out cannot swim. It is just as likely to start toward the bottom of the tank or to go on its side or in any other direction as to swim forward. Animals with even severe lesions of the cerebellum will jump from a height as great as this table and alight on the floor, sprawled out to be sure, but they do not come down with a crash and bump the chin. A dog with a severe cerebellum lesion may swim even better than it can walk, so there are two typical vestibular symptoms which are not present in cerebellar lesions. Again, one can get typical vestibular nystagmus when there is complete ablation of the cerebellum in animals. Furthermore, a positive Romberg sign is present in disease of the vestibular system, but a positive Romberg sign is not a characteristic symptom of cerebellar lesions.

More recently, I have come back to work on the internal ear, not so much with reference to the mechanism of nystagmus as to the cognate question of the relationship of the vestibular system to the position of the head and the control of its movements. I had one cat, operated on nearly two years ago, with a puncture wound of the cerebellum. Tremors of the head were rather marked for a time, but there was practically complete recovery so that the only thing which I could notice was a fine tremor of the head when the cat was looking at me intently. In January, 1928, I took out one vestibule. The animal recovered from that and showed few symptoms. In April, I removed the second internal ear, and from that time until August there were uncontrollable movements of the head and great unsteadiness of gait, neither of which follows for so long a period simple removal of both internal ears. I followed a suggestion of Hughlings Jackson here. Jackson had the idea that after injury to one level or pathway of the central nervous system there would be about the same total quantity of nervous energy flowing through the remaining level as flowed through the whole system before. He expressed these views before the development of our modern ideas of the conduction of nervous impulses. At the present time, one would say that what Jackson meant was that one pathway could take on an overload of function when there was an injury of some other. I strongly suspect that some of the recoveries from cerebellar lesions are due to the increased function of the vestibular system following the cerebellar injury. The vestibular system is concerned primarily with the perception of the aspect or change of aspect of the head in space. So long as there persists one mechanism for the control of movements of the head, either the cerebellum or the vestibular system, the animal may recover from a lesion of the other fairly well. When both are gone, the condition is much more serious. It may be added that objective experimental proof of Jackson's view has been found in the relations of the vagus and intercostal nerves to the control of respiratory movements. A lesion of either set of afferent nerves, both vagi or the dorsal roots of the thoracic nerves, is attended by a considerable degree of recovery; but when both sets of afferent nerves are injured, the symptoms are far more serious.

About the matter of vertigo, just a week ago I had an animal in which both internal ears had been removed in the morning. It had recovered from the anesthetic and was rolling about on the floor. It grabbed a piece of meat with one paw and held on to the cross bars of a table with the other, meanwhile trying to force the meat into its mouth. An animal with both vestibules out is extremely helpless for about ten days. After that it begins to get along fairly well, that is, it shows few disturbances of motility so long as it remains in contact with the

floor. It seems to me, from what I know of things now, that both cerebellar and vestibular afferent impulses are summed up or integrated in the control of body movement in normal animals, but where this integration occurs I do not know. I am fairly well convinced that the cerebral cortex, or some part of it, is necessary for typical vestibular nystagmus in the human being, and I am fairly well convinced that the cerebral cortex, or some part of it at least, is necessary for the reaction of vertigo. How the various afferent impulses are integrated, how the various cell groups and fiber tracts are unified in their operation, I do not know. It has seemed to me that one must use terms that in general convey the idea of a mechanism or machine. I greatly fear that our descriptions of nervous mechanisms would not work in a Ford engine. There is too much inhibition, and whenever one uses the term inhibition one can be perfectly certain that one is talking about something concerning which he knows nothing. Other terms of equally vague meaning are used whenever one gets into trouble, which is generally always. It would be better to drop such terminology and say that one does not know. One would be in a better position to find out some things and the reasons for certain occurrences if one were to say that, than one is when one tries to delude himself by using terms of vague or meaningless signification. I might have talked to you about inhibition — external, internal or eternal — but I would not have known what I was talking about, and neither would you.

I am not quite convinced that muscle sensation is necessary for vertigo, although the presumption of truth may be strong. I have had vertigo myself at times. I was not really trying to put myself in the cat's place, but I have had personal experience. When one is lying down quietly and the head of the bed seems definitely going down and over to the right, one is not conscious of any muscular movement, but one may get a very disagreeable sensation or impression of movement. It seems to me that the mechanism involves the cortex.

I think that Dr. Hoyt is to be commended for his analysis of the subject of vertigo. I do not believe he thinks that it is the final analysis, but it is one of those cases in which progress is made by adding up and reexamining the results of experience from time to time, and perhaps changing our views from what they were previously.

DR. MARVIN F. JONES: Professor Pike is considered among the first six in authority in the world in this particular line of research, so to try to supplement anything that he has said would be impossible. There is one thing which I want to bring out: When one makes a rotation in the chair, with the head in the position described by Dr. Hoyt, one gets a very peculiar reaction. There is extension of the left leg; also, the drawing back and to the right of the head; extension of the left arm, and flexion of the right knee and arm. If I were walking, stubbed my toe, and was afraid of falling, my foot would come out, my arm would extend and my head would go back. The sensation after rotation corresponds to the sensation of falling. It is not always a rotatory, but a pitching sensation, with the head in the position described. The reaction to that particular sensation would be an endeavor to keep one's self from falling in the direction in which he thinks he is going to fall. Consequently there is this protective reaction reported by Tait and McNally.

The point of having a better definition of terms, that Professor Pike brought out, is one of the first on the list of my discussion. I looked "vertigo" up in the dictionary, and was astounded to see what vertigo meant. Another word is nystagmus. There is a misnomer in nystagmus, and it is necessary to pin this nystagmus down to definite terms. If a patient looks ahead, or to one side, and develops a nystagmus, it is just as easy to make a calibration of some sort in order to measure the degree and call that nystagmus with the quick component to the left so many degrees, as to say "down," or "laterally," or "up." Nystagmus has been named from the direction of the quick component. A vertical nystagmus is said to be one that goes straight up and down. These are misnomers.

When I said I would discuss this paper, I asked if I could put in a bit of propaganda. The field is common to both the ear specialist and the neurologist.

I believe that the combination of the physiologist, the neurologist and the otologist can make something out of this if autopsies and complete observations are secured in these cases. One must have the complete records, regardless of what is found. After one has the observations on paper, and the patient dies, then serial sections of the brain and cord should be made, to see if one cannot work out by the degeneration exactly what pathways are involved. In this way some light may be thrown on the subject. I found an article by Barre in the ARCHIVES OF NEUROLOGY AND PSYCHIATRY which is one of the best reviews on the vestibular apparatus that I have ever seen. There are four little paragraphs at the end, following about fifty pages on this particular subject. I think that it is a very good summing up:

1. Thou shalt not accept current schematic ideas too quickly, too completely, or too long.

2. Thou shalt be objective, telling thyself that the patient is always right and that he presents facts which thou shalt first take down, even without understanding, in order later to obtain an idea.

3. Thou shalt employ only the terms which express exactly the facts which they indicate or signify.

4. Thou shalt accustom thyself to terminate long reflections by saying that thou hast not understood and that thou canst not conclude.

NEW YORK ACADEMY OF MEDICINE, SECTION OF NEUROLOGY AND PSYCHIATRY

Regular Meeting, Dec. 11, 1928

JUNIUS W. STEPHENSON, M.D., *in the Chair*

A CASE OF INTERNAL HYDROCEPHALUS OF UNKNOWN ORIGIN SIMULATING BRAIN TUMOR. Presented by DR. JUNIUS STEPHENSON and DR. FRITZ CRAMER.

This case belongs to a certain large group of cases simulating brain tumor in which only an internal hydrocephalus is found, without pathologic changes to which the obstructive lesion can be attributed.

Clinical History.—The patient, a white man, aged 28, of Serbian extraction, an electrical engineer, was admitted to Dr. Kennedy's service in the Neurologic Institute on Sept. 12, 1928, complaining of pain and stiffness in the neck for six months. The illness began in April, 1927, with severe, spasmodic, bitemporal headaches. These continued for about eleven months, until February, 1928, when they were superseded by the pain and stiffness in the neck. Since Sept. 1, 1928, he had had occasional attacks of blurred vision in the left eye; there was no diplopia.

Examination.—The head was tilted toward the right, the neck being held stiffly; the stiffness, however, could be easily overcome by relaxation of voluntary control. There were no meningeal signs. The deep reflexes were somewhat exaggerated, but equally so; the abdominal reflexes were normal at the first examination. The pupils were equally enlarged, but were otherwise normal; there was a fine nystagmus in both directions in extreme lateral gaze. There was also a slight general pallor of both nerve heads.

Laboratory Tests: The serology of the blood and spinal fluid was normal. The urine showed a faint trace of albumin, a few leukocytes and a few hyaline casts. The spinal fluid was under abnormal pressure, 295 mm., before any fluid was withdrawn, but there was no evidence of block.

Roentgen Examinations: Except for rudimentary attempts at rib formation on both sides of the seventh cervical vertebra, the vertebrae appeared normal. The skull showed some calcification in the region of the pineal gland and of the choroid plexus. There was also some evidence of atrophy of the dorsum sellae. After an attempted encephalogram by the injection of air through the lumbar route no air was seen within the cranial vault, although it was present in the spinal canal below the foramen magnum. After an injection of air into the ventricles a markedly dilated ventricular system, of even outline, was observed, the third and fourth ventricles being proportionately more involved than the lateral ventricles.

Course.—The patient was definitely somnolent by day, though he apparently slept well at night. About a week after admission he was found to have a paroxysmal external strabismus, particularly in the right eye, without demonstrable weakness of the extra-ocular muscles. This became more frequent and was followed later by rather severe generalized headaches and paresthesia of the right arm without objective sensory disturbance. The abdominal reflexes became feeble and frequently could not be elicited; when present, the left were always more active than the right at this time. Because of the signs of increased intracranial pressure, a lumbar encephalogram was attempted on Oct. 23, 1928, but only 48 cc. of fluid was obtained; the flow became extremely slow, and slightly bloody; 40 cc. of air was injected, but none of it reached the cranium. A ventricular injection of air, on Nov. 1, 1928, revealed a massive hydrocephalus. This procedure was followed by headache and somnolence, and by sudden death from respiratory failure sixty hours later.

Necropsy.—The brain only was examined; no gross evidences of the cause of the hydrocephalus were found, although there was abundant evidence of increased intracranial pressure. The left lobe of the cerebellum was somewhat larger than the right.

Microscopic examination of the central part of the right cerebellar lobe gave negative results. Sections of the meninges over the foramens of Luschka and Magendie, of the right sixth cranial nerve, of the pons, including the ependyma of the fourth ventricle, and a section of the right frontal cortex showed no signs of inflammation or neoplasm.

Conclusion.—The general symptomatology can be explained on the basis of an increased intracranial pressure due to hydrocephalus. Likewise, the failure of the lumbar encephalogram was due to wedging of the cerebellar tonsils into the foramen magnum. For the present, however, the case must be regarded as one of hydrocephalus with no demonstrable etiology. One can only presume that there may have been a general inflammatory or neoplastic process, so minute in size as to be incapable of demonstration by the studies made thus far.

DISCUSSION

DR. STEPHENSON: To me the interesting thing about this man is the behavior of the manometric tests and the lumbar encephalogram.

DR. FAY: I have not had an opportunity to view the plates, but it seems to me that there is definite evidence of an obstruction, probably in the posterior fossa or in the outlet of the ventricular system, in such a symmetrically dilated shadow. The process is apparently one of long standing; otherwise the dilatation would not have reached that degree without definite intracranial symptoms and some ocular changes.

I have seen one case that offers a possible explanation why air did not reach the posterior fossa; the cerebellar hemispheres sagged down into the foramen magnum, precluding thereby the possibility of air reaching the supratentorial space. The cause for this obstruction, of course, was not evident, but I believe that, in all probability, with that amount of ventricular dilatation there might be expected a displacement of the cerebellum in the direction of the foramen magnum, making a cerebellar hernia; in the presence of that, a manometric examination might be of value.

A Case of Pseudobulbar Paralysis with Unusual Pathologic Observations. Presented by Dr. Lewis D. Stevenson.

I present the brain of a woman who was on Dr. Kennedy's service for over a year. She showed the classic picture of pseudobulbar paralysis. She was only 31, and yet the amount of atrophy of the brain and its small size are remarkable. The brain at necropsy weighed only 880 Gm., that is, only about two thirds of the average weight of the normal brain. The pathologic change is mostly in the cortex of both hemispheres. The shrinkage is most marked in the precentral and postcentral gyri on both sides, although some atrophy may also be observed in the frontal and occipital lobes. In making the first cut of the brain it appeared as if there were no lenticular nucleus on one side; this nucleus, however, is there, but owing to the difference in the size of the hemispheres it is barely visible. The same is true of the left thalamus. Further sections showed that the basal ganglia and internal capsule are grossly intact; so far I have been unable to find any lesion there microscopically. The ventricles are perhaps a little dilated as they would be in any atrophied brain. The large arteries at the base of the brain are not extensively involved as compared with the others, but the internal carotids are extremely small and sclerotic. There is hardly room for a bristle in one of them. The other is about the diameter of the lead in a lead pencil.

The rest of the necropsy report showed heart disease, chronic endocarditis, small red granular kidneys and arteriosclerosis of most of the other organs. The Wassermann reaction was negative, and as far as I know there was no suggestion of syphilis.

Microscopic Examination.—A section from the left frontal lobe, stained by the Weigert method, showed a certain amount of loss of myelin. A section from the motor region showed a total loss of myelin as well as great destruction in the gray matter of the convolution. In sections stained with hematoxylin and eosin a great many of the vessels were thrombosed; the smaller vessels near the surface were completely thrombosed. With the van Gieson stain the motor region on the left side showed a great band of fibrous tissue. Strangely, there was little glial reaction; only here and there were there islands of gliosis. A section of the lenticular nucleus on the left side, stained by Dr. Globus' method, showed little destruction in this nucleus. The cortex showed microglia cells of various sizes, with many fatty cells and broken down tissue.

DISCUSSION

Dr. Kraus: I saw this patient at Bellevue. I am particularly interested in regard to one point — whether the clinical manifestations of pseudobulbar paralysis could not also be considered "flaccid cortical paralysis." One may recall that Bergmark (*Brain*, 1909) reviewed the cases of flaccid paralysis in the legs and arms of cortical origin and definitely showed that flaccid paralysis does result from such cortical lesions. In this case, Dr. Stevenson has shown that the pathologic process is limited to the cortex. It would seem that there is a clinical picture of pseudobulbar paralysis which may also be called flaccid paralysis of cortical origin.

The Convulsive State and the Results Obtained by Fluid Limitation. Dr. Temple Fay.

This paper will be published in full in the Archives.

DISCUSSION

Dr. Elsberg: I wish to thank Dr. Fay for having presented this matter and for having suggested a therapeutic point of view which may be of great value. No matter whether grand mal attacks are secondary and the truly essential part of what is called epilepsy is the petit mal attack — a view with which I, personally, thoroughly agree — any therapeutic measure which will diminish the frequency of grand mal attacks or cause their disappearance altogether is a matter of great importance.

Some of the views expressed by Dr. Fay, with perhaps one exception, are very much like my own. Everyone who has operated on patients with convulsive seizures, no matter from what cause, has seen an increase of fluid under the arachnoid, and many have believed that this increase of subarachnoid fluid was the essential factor in causing convulsive seizures. As a result many have attempted to evacuate this fluid at the operation, and some have believed that they obtained therapeutic results. Perhaps they did, as far as grand mal attacks were concerned, obtain results by this "dehydration" treatment.

I believe that the mere presence of fluid in the subarachnoid space is not the factor that causes convulsions, but that, in the presence of fluid, they are caused by a sudden increase of that fluid with resulting pressure on and anemia of the cortex itself. In other words, an increase of fluid under the arachnoid, as occurs in those who are subject to convulsive seizures, leaves the cortex in a much worse situation so that a sudden increase of fluid will cause an added amount of anemia of the cortex; this is not necessarily an increase of "intracranial" pressure, but an increase of cortical pressure. As a result, whether there is an added toxemia or not, an irritation of the cortex is brought about which may result in grand mal attacks. From this point of view it seems to me that treatment by limitation of the fluid and by dehydration both by limitation of the fluid intake and by the use of hypertonic solutions may and should have exactly the effects that Dr. Fay has described. A large number of cases must be studied before one can come to a definite conclusion. Cases such as those described by Dr. Fay, which have been carefully studied for a period of from one to two years, show one direction that therapeutic efforts should take.

DR. FOSTER KENNEDY: I have little to add to what Dr. Fay and Dr. Elsberg have said so well. To this day there are many physicians along the Gold Coast who are much annoyed because Lloyd Ross, as they say, came around and gathered all their information and then created a theory as to how to cure malaria. Ross collected many half digested theories on the relationship of the mosquito to malaria and produced a perfectly clearcut picture. It is to Ross that we owe our knowledge of how to deal with malaria and the life history of the disease.

Probably everybody, after listening to Fay, looks back on his experience and realizes that here and there he himself half touched or perhaps completely touched the idea and then forgot that there is an increase of subarachnoid fluid in epilepsy and that there is some relationship between that fluid and the attacks. One will think of the alcoholic wet brain, senile epilepsy, associated with contraction of the brain and increase in fluids, uremic epilepsy with its edematous conditions, eclamptic epilepsy with the same state, and certain cases of angioneurotic edema of which I talked at one time. We all have observed increase of subarachnoid fluid associated with convulsions, but it has remained for Fay to bring the matter clearly to a head and to suggest a line of treatment. While this is an inadequate number of cases to prove the real efficacy of the therapy, it is a good start.

DR. STRAUSS: Certain phases of this work and its applicability are not clear to me, especially when it comes to drawing conclusions. I was gratified to hear Dr. Fay speak of the convulsive state and then subconsciously talk about epilepsy. I am of the old fashioned type and still adhere to the word epilepsy, because to me that denotes a clinical syndrome which is distinctive, that occurs in persons generally not over 35 years of age, that is periodic in appearance and in which thus far no definite pathologic process has been found to explain its cause.

When reference is made to convulsive states in general, I think that there are brought into consideration many conditions which are different, as we know they are etiologically, from the so-called idiopathic epilepsy, foreign as that term may be to some.

There is no question that in many of these cases of epilepsy there is an external hydrocephalus. Dr. Fay has demonstrated that definitely, and in our hospital my colleagues and I have also demonstrated its presence on numerous occasions by use of the method of encephalography. It is also true that in some cases one finds

an internal hydrocephalus combined with an external hydrocephalus. Unquestionably, Dr. Fay has shown that through dehydration in certain cases the number of convulsions can be limited. We have had the same experience in using the method of fasting. It may be that Dr. Fay thinks that this other method has depended, to a certain extent at least, on dehydration for its results, and yet recently Cobb and Lennox showed that fasting is not efficacious to any great extent; it had some influence in a certain number of their cases, as other methods have, but by and large it was not potent.

The ketogenic diet has likewise failed in many instances; in others it has helped.

When one looks at the physiology of this condition and talks about the increased fluid acting as an irritating factor on the cortex, one must not forget that, also recently, Davis and Pollock showed by their method of interfering with the circulation that one can have convulsive seizures, both tonic and clonic, from disturbances in the brain stem. The cortex need not be a factor. One cannot say absolutely, therefore, that the irritative phenomena releasing these convulsions are altogether due to the cortex.

Again, when one speaks of vasomotor disturbances, I think one must admit that as yet one is not absolutely certain; it cannot be said with certainty that there are vasomotor nerves controlling these vessels. That does not mean to suggest that the vessels do not contract and dilate, because it is known that they do. The contraction and dilatation may be due to myogenic factors, factors influencing the muscle walls themselves, but I am not certain that it is permissible to call in that physiologic process as the factor underlying these things.

Dr. Fay unquestionably, by his method of dehydration, has reduced the number of convulsions, but something else must be brought in here for consideration, for me at least, if one is to accept this theory in its entirety; the external hydrocephalus which is demonstrable must be more or less persistent, and while there may be slight variations from time to time in the quantity of fluid contained within the skull, nevertheless I cannot conceive of a variable in ordinary life of such degree as to bring on convulsions at one time and their absence at another.

Furthermore, one must admit that, in many cases of varied types of epilepsy, phenobarbital, ½ or ¾ grains (0.03240 or 0.04860 Gm.) will cause cessation of attacks for as long as a year or longer, and that other drugs will do the same thing.

What Dr. Fay has demonstrated to me tonight is that here is one factor, and I believe that probably he thinks as I do, which may be of influence in the production of the convulsive condition, but that there are other factors, underlying factors, the nature of which may be discovered in time by further research. As a step forward Dr. Fay's work is, I think, of great value. I want merely to point out, as I have done on other occasions when I have heard of other cures, that behind the whole question of idiopathic epilepsy there is an as yet undiscovered, underlying factor which remains for future work to discover.

DR. OSNATO: I am sure that Dr. Fay will not take my remarks merely as a criticism. Dr. Fay's work is important indeed. It occurred to me, however, that it is perhaps not so much the fluid on the cortex that matters as what the fluid contains. Conceiving the body for the moment as a laboratory, it probably manufactures endogenous and perhaps takes in exogenous poisons, the number of which vastly exceeds the great number of convulsive agents known in the physiologic laboratory. The factors at work in epilepsy, it seems to me, cannot be reduced to one so simple as that which Dr. Fay has so ably developed. It occurred to me that perhaps he had not thought sufficiently of the cases of traumatic headache in which at operation observations were made exactly similar to those he described. These were first described by Trotter, who was enthusiastic about operating on patients with localized headache following injury because he invariably found on opening the dura that there was a localized collection of fluid in the arachnoid space over the bruise. He did not operate for epilepsy; he operated for localized headache. Penfield recently described operations on patients with severe traumatic headaches, none of whom had epilepsy. Consequently, it is possible to have local-

ized and extensive collections of fluids on the brain with a second sensitizing factor, the trauma, and yet not have epilepsy. There must be, as Dr. Strauss said, other factors, perhaps many others.

My interest in the subject of epilepsy has been along the lines of biochemical studies, and I think that sooner or later one will find a great group of factors, many of which operate as sensitizing agents. An increase of intracranial pressure, a question taken up by Dr. Elsberg, may be a factor. One of them undoubtedly is trauma. But these alone and perhaps even the fluid collections, the external hydrocephalus, do not cause epilepsy. The factor mentioned by Dr. Fay, alone or in combinations, in the absence of a convulsive agent, manufactured entirely independently of anything in the central nervous system, in my opinion is not enough. Single theories, developing separate points of view, will always be insufficient alone to clear up the problem of the convulsions in epilepsy.

DR. FAY: Dr. Elsberg stressed the operative means that had been attempted to produce results. This is a nonoperative procedure. I hope that none have mistaken the fact that I have cited a group of clinical observations over a period of twenty months in which I have noted a phenomenon. I am not capable of explaining it. I have tried to make it clear that I have drawn no conclusions. I have not attempted to do more than build on the work of others as Dr. Kennedy has said. For two years I have searched the literature in order to try to find the proper adjustment. I have been as hypercritical as Dr. Osnato and Dr. Strauss. Dr. Spiller has thought that the results have sufficient value to arouse your interest. I have been far from feeling that this is a definite, positive means of treatment, and I certainly do not intend to convey that this is to be considered in any sense a cause or cure of epilepsy. It is a peculiar phenomenon.

Dr. Kennedy has brought out that the men who have done the work and have brought about this little clinical experiment are the men who deserve all the credit. I have simply taken the idea of dehydration from my own work of four or five years ago on controlling intracranial pressure, and have applied it. It will take five years longer to tell what the result means. Dr. Strauss has noted several things. I wish I could have given my full paper, in which I have taken up those factors, to Dr. Strauss.

I have studied Dr. Osnato's work carefully. Poisonous substances in the spinal fluid have not been demonstrated. Furthermore, in status epilepticus — and I have had seven experiences in which two patients were in status epilepticus at the time I operated — if one opens the dura, the attack continues; if one incises the arachnoid and lets out some of the fluid the seizure terminates in ten minutes. If a substance was diffused over the cortex it could not have been drained off in two or three minutes. It is the relief of tension that is effective.

Dr. Elsberg has brought the matter to a head, and that may explain why this factor applies in one case and not in another; if there are distended trabeculae under fluid tension, constantly pulsating with the arterial flow, does one not have perhaps a focal irritation sufficient to produce a response? One knows that it cannot be produced by rubbing a finger over the cortex, or by incising the cortex with a knife; it requires freezing or some irritating drug.

Those are thoughts; one has no proof. I want, if I can, to emphasize that these are a group of observations. They will not follow or be obtained in cases in which one does not get absolute cooperation and in which the fluid level is low enough to maintain dehydration. One will not be able to control petit mal attacks unless one finds something more than I have in my treatment. The mentally defective and chronic cases are going to be more difficult to handle.

I have come to view epilepsy in the same light as syphilis. Can the tertiary stage of syphilis with tabes and paresis be cured? One may stop syphilitic infection, but can one repair the central nervous system when the damage has been done? One can control a mechanism which may produce a damage. Can one hope perhaps in an early case, with cooperation, to help that person in the future? I feel sure that one is not going to be able to help the institutionalized or chronic mental case any more than one can accomplish this in the tertiary stages of syphilis.

SEGMENTAL HYPERALGESIA AND SEGMENTAL INCREASED MUSCLE TONE IN DISEASES OF THE LUNGS AND HEART. Presented by DR. JESSE G. M. BULLOWA.

Distensile pressure in the heart and lungs has definite projection patterns on the skin, revealed as pain or lowered threshold to the perception of painful stimuli, or by increase in the muscle tone, as revealed by changes in the shape of the thorax, or by diminished vital capacity. The skin and muscles involved are those of the segments from which the viscera develop, and from which they receive their nerve supply.

The reflexes from the lung have an area of cervical representation, third and fourth cervical, evidence of their entodermal origin as an outgrowth from the pharynx at that level. They have also a vascular or parenchymatous representation, seventh cervical, which witnesses the fact that the pulmonary capillary bed originated in the postbranchial plexus, in the dorsal region of the midthoracic region.

Irritation in the trachea and bronchial tree gives rise to cervical hyperalgesia and increased muscle tone. Congestion or inflammation in the lung substance gives rise to thoracic hyperalgesia and increased muscle tone. In pulmonary tuberculosis both areas may be involved. Late in the disease, with wasting, the thoracic zones disappear. In pneumonia, when consolidation is complete, the capillary bed is occluded, and the alveoli are filled with exudate. At this time, the hyperalgesic zones are not elicitable.

Emphysema may be of two types, cephalocaudal or lateral, depending on the tissues most involved. Epinephrine, which acts largely on the blood vessels, is useful in asthma when the thoracic zones are involved as revealed by thoracic hyperalgesia.

It is suggested that the shape and development of the chest may be more effectually modified by influencing the factors which govern nutrition and consequent fulness of the lungs' capillary bed than by posture exercises or training.

In diseases of the heart, the reflexes arising from the aorta are referred from the second and third thoracic segments; those from the auricle, to the sixth anterior maxima, and those from the ventricle, to the fourth and fifth maxima. The fourth and fifth segments are the only segments in the body which have lateral as well as anterior and posterior maxima of Head, or areas in which hyperalgesia is present, though the entire segment is not responsive. Hyperalgesia in the lateral maxima appears before the anterior and posterior maxima and persists after they have become insensitive.

The evidence for postulating the relation of these areas was set forth. The importance of observing dermatome irritation in connection with muscular spasm, in the differential diagnosis of thoracic and abdominal disease, was exemplified.

DISCUSSION

DR. GOODHART: Dr. Bullowa's observations, I know, cover a period of a few years and his deductions, therefore, may be given close consideration. The paper is based essentially on the early work of Ross and the later amplifications by McKenzie and Head. The theories of Head, on which he based his observations of the relation of the visceral pathology and segmental spinal control, have been fully discussed and amplified since the original papers. There can hardly be a question but that the sympathetic and autonomic nervous systems are the mechanisms through which these associations are established. I would say that the results obtained by Dr. Bullowa demand for their accuracy considerable technical experience. The accurate establishment of definite points of maxima of hyperalgesia assumes a technic which every man must establish for himself; there are several variants to be taken into consideration, especially the variation in the threshold of sensitivity in different persons as well as the relative sensitivity of various zones of the integument. The reader of the paper has given us a study of the influence of pathologic processes of the lung and corresponding segmental reactions and, it seems to me in a very scientific way, showed us why the third and fourth

cervical segments and the sixth and seventh dorsal should be the areas of investigation. He had gone a considerable degree further in bringing into a clinical picture the influence of the viscera on muscle tone in the corresponding segmental areas. As I understand it, Dr. Bullowa finds the important pathologic processes of the lung represented by the vascular system of the lung and gives its level of segmental representation as the sixth thoracic. Very ingeniously he builds up the unified representation and sees the pathology of pulmonary lesions divided into that which represents: (1) the upper air passages including the bronchi and (2) the lung tissue and vascular mass. Furthermore, as I see it, he establishes that when the tissue is performing its function normally there are no areas of hyperalgesia, and likewise when, in the case of an external loss of the blood mass, or, as I would take it, when the pathologic process within the lung is profound, the visceral reflex, that is, the afferent paths from viscus to center, no longer carries irritative stimuli and the hyperalgesia disappears; again with the approach to normality the abnormal segmental sensitivity returns — that is to say, the threshold is lowered to pain stimuli. Thus these segmental areas become indexes of the pathologic process. Here I may say that it must take a great deal of personal experience and technical perfection for exact conclusions. The reader's conception of the visceral influence on blood vessels and muscle tone and these again on physical structural development is contrary to prevailing thought. His theory has an important influence on therapeutic methods. One might ask, does it not assume that irrespective of biologic genetic factors the physical development of the individual is determined almost entirely by conditions after birth? On the whole, I want to say that the paper is most inspiring and urges us to direct our inquiries into clinical observations so that each for himself may get what appears to be a help in the diagnosis of visceral lesions. I personally have not applied the theories of Head to my own studies sufficiently to form a definite opinion. I can see many difficulties in the way of coming to a definite conclusion without a great deal of study and observation in a great variety of pathologic conditions.

DR. KRAUS: Dr. Bullowa has done us a service. His paper emphasizes a viscerosomatic reflex to which too little attention is paid. He brings to light, as Dr. Goodhart has so well emphasized, the importance of understanding the embryology of the body as a means of interpreting the manifestations of disease within it.

I shall mention only one idea which the paper has suggested. It is interesting that there are two evidences of lowering of the threshold in the reflexes which he has described. One of them is evidenced by hyperalgesia, in which an ordinary stimulus produces pain which under normal circumstances does not occur. The other is evidence of hypertonia, lowering of threshold, in the muscles of the chest which is evidence of release of control by suprasegmental structures. Whether the pathway over which the reflex passes that produces the manifestations which Dr. Bullowa has described passes beyond the segmental system and up into the suprasegmental system is something that would be difficult to state from the clinical evidence presented.

Two things at least have come out of the paper. One is the advantage of adding a thorough investigation of a problem from points of view other than clinical, and the second that neurologists can learn a great deal about the nervous system by listening attentively to those who are not neurologists.

Book Reviews

GEFÜHL UND ERKENNEN. VON J. S. SZYMANSKI, Vienna. Supplement No. 33 to Monatsschrift für Psychiatre und Neurologie. Price, 12 marks. Pp. 198. Berlin: S. Karger, 1926.

In the introduction the author reviews the subject of feelings and emotions. The structure and quality of feeling are discussed. Feeling is an extremely vague concept in modern psychology. The concept of the term is poorly delimited. On the one hand, one understands feeling in the sense of all nonintuitive experiences; on the other hand, one understands under this term all experiences which can be classified according to the pain and pleasure principle. The author gives a historical review of the evolution of the psychologic term "feeling" especially in connection with the tridimensional theory of feeling by Wundt. The author criticizes Wundt's point of view and states that when feeling is looked on as a state of consciousness it cannot conform with the tridimensional theory; on the other hand, when feeling is understood only in terms of pain or pleasure it is also unsatisfactory, because then Wundt's theory becomes superfluous and misleading. In the absence of any delimitation of the concept feeling it is best to analyze it in terms of the quality and structure of experience. Analysis of experience in terms of pain or pleasure is too theoretical and schematic, because in reality one does not find a clearcut existence of pain and pleasure, and from this point of view they are really abstractions. Only through the section and analysis of emotional states in human beings can one get a clear conception of feelings as they occur in actual life. The insane offer unusual opportunities for study of feelings on account of the intensity of their emotional life. By studying the feelings in the insane one gets the same picture as if one were studying them in normal people under a large magnification.

One hundred female patients of the Psychiatric Clinic of the University of Vienna were selected for the analytical study of feelings. Women were selected in preference to men on account of the naturalness of their emotional life. As far as the author is concerned, he does not recognize any difference between affect and feeling, stating that they differ only in the intensity of their emotional reactions.

Chapter II describes the observations on the clinical material. The author describes states of unrestrained joy. The patients who demonstrated this condition showed elation, marked heightening of the emotional tone and some mischievousness. They were boastful and overtalkative. There was marked overestimation of their own abilities, especially in the intellectual sphere. The patients thought that they knew everything and could do anything. The euphoria, elation and grandiose ideas of the patients were analyzed in their relationship to each other. The grandiose ideas reached the feeling of omnipotence and feeling of participation with God or, at times, a feeling of identification with God. The feeling of unusual abilities is usually based on some special accomplishments which the patient may possess. The future is seen in a rosy light. As the past is of no consequence, there is a carefree attitude toward life. Any steady monotonous task becomes distasteful, and frequent change of experiences becomes an urge. The same feelings of uninhibited joy may be present in normal people under unusual conditions, but they persist only for a short time.

The second type of pleasure deals with feeling associated with a sense of increased power. Under this heading comes feeling of omnipotence and mystic participation with the Creator. Six patients showed this condition. Through hallucinations and delusions, the patients conceived the idea that God was with them and acting through them. This feeling of omnipotence gives to the patient a sense of security, happiness and joy. It helps the person to solve his problem,

to define his attitude to the world and to solve the conflict between the ideal and the everyday life.

Increased recognition or perception implies a better contact of the subject with the object. Recognition is a process of assimilation of new experiences into one's self; it is making a new and richer personality. The author compares the feeling of pleasure with a normal sensation which one gets on looking at a beautiful picture. You look at a beautiful landscape or a simple theme such as that expressed in Raphael's Madonna and at first you see simply a rather good looking woman with a child in her arms. Then all of a sudden, like lightning, you get the joy of the picture. You see how beautiful the Madonna is, you perceive the spiritual beauty of the mother, you suddenly become aware of the God-child — all of which suddenly gives you sharp pangs of joy, One gets similar feelings suddenly on seeing a beautiful landscape or on seeing the ocean for the first time. Recognition is thus closely tied up with feelings. In primitive people and children it is associated with prelogical thought, as explained by Levy-Bruhl. Insane people have the same feelings as normal people, the difference being in the degree of reaction to the experience.

Pain can be described under three headings: (1) Pain due to a feeling of impotence, insufficiency and weakness which is associated with a feeling of emptiness in the head, stupidity, mental and physical weakness and a feeling of helplessness, uselessness and resignation. (2) Pain due to anxiety states with feelings of impending danger, fright and fears of death. (3) Pain due to anger and irritability. In this condition the patient feels that there is somebody else at fault. It is usually the husband who is ungrateful and the daughters who are disrespectful. The patients who suffer from this condition are people of extremely sensitive disposition with an exaggerated feeling of self estimation. They are usually extremely quarrelsome. They have a much greater estimation of their abilities than is justified. They fail in their ambitions, and they solve the problem by blaming somebody else. Practical life either gives no opportunity for the outlet of the abilities, or else there is a marked discrepancy between the self estimation of ability and the actual amount of ability possessed. The anxious person gets anxious on account of anything and everything. The irritable person becomes angry toward anything.

Emotions should be classified from the point of view of quality, structure and subjective experiences which correspond to the emotions. The quality of emotions deals with them from the point of view of pain and pleasure. The structure deals with the corresponding clinical manifestations of emotions. The author makes a diagram of several concentric rings with various emotions occupying various sections of the outer circle, with pain on one pole of the circle and pleasure on the opposite. The structure of the emotions is classified on the inner ring.

In the classification of feelings, one should take into consideration also the so-called signs of emotion postulated by Lotze. Feelings can also be classified into high and low. Low feeling covers simple reaction to situations accompanied by a definite feeling tone, while higher feelings concern themselves with complicated states in consciousness and recognition. Taking up the question of will, the author states that while feeling deals with simple, not intuitively conscious impulses and drives, will deals with intuitively conscious impulses.

The second part of the monograph deals with the problem of recognition. The author tries to demonstrate the close relationship between drives in the person and the process of recognition. As previously, the same method of pathologic variation is employed. For this purpose the ideas of the paranoid patients were utilized. The difference between the paranoid and the normal person lies in the following: that which exists in the normal person as a wish becomes a reality for the paranoid patient. The logic of the paranoid patient follows the same laws of thought as that of the child, of primitive man, and of dreams. The author tries to clarify the relationship between the drive and recognition. In the first place there is the determination of direction of active recognition of the outer world through exaggerated drives. Delusions of persecution and of jealousy

are brought to illustrate this point. Extreme subjectivity of evidence and special judgment characterize the thought processes of these patients. The proofs are supplied either through false sensory impressions, such as hallucinations, or by false conclusions. Hallucinatory experiences are the most direct proof of the validity of their statements. They often confuse the cause and effect. The patients believe that they have desires or feelings because they heard them in the form of voices. As a matter of fact it is the other way around. The wish is the cause of the particular thought or feeling which the patient experiences. They are projected outward as ideas or sensory experiences. A patient who wanted to leave the hospital told the physician that he did not care whether he remained in the hospital or not, but he heard voices commanding him to go. Patients in love hear voices telling them that they will marry. The significance of delusions and hallucinations lies in the demonstration of the inadequacy of the person, in demonstration of the incongruity of fantasy and reality. It gives the person the most beautiful fantasy for sordid reality. The dream fulfils the same function.

The incongruity between the meaning of the patient's utterances and the words themselves can go so far that each word may have the content of a whole sentence. The second method used by the paranoid patient as a proof of certain ideas is that of a formal logical dissertation. The intensity of the drive is so strong that most absurd statements are made in a setting of clear logical propositions. It is not the logic but an extremely subjective point of view which makes for absurd statements. When the logic of the psychotic patient is analyzed, one finds that the conclusions may be correct but are based on false premises. The direction of recognition may be quite independent of the material of experience. Thus, in elation or depression the whole outside world is changed, although as a matter of fact the world remains just the same. The changed point of view is due to the internal drive of the psychosis. The same conclusions may be arrived at although the experience is different. This is due to two totally opposite sets of beliefs. It may be due to two opposite drives within the patient.

An increased drive means an increase in the mechanism of cognitive phenomena. Thus, as the result of a psychosis the patient tells of experiences in the past which, although they fit in with the present ideas of the patient, in reality have not taken place.

The drives which influence the patient are often personified. The patient describes the onset of his religious ideas in the following words: "A wind came over my head." The patient speaks of strange powerful forces, magic influences which make him act in a certain way.

There is no fundamental difference in the actual thought process of the psychotic and the normal person. The only difference is in the drive of the normal person which is controlled and regulated by the thought processes that demand absolute objective evidence as a prerequisite to the formation of a belief. Yet, in a dream state where critical judgment is suspended for a time, exactly the same sort of thing happens which one finds in the psychotic patient.

The author traces the various philosophic systems in the light of various drives in the philosophers themselves.

Hallucinatory experiences in a normal person have a certain reality value when they occur in a dream. As a matter of fact, some artists, musicians and writers often have hallucinatory experiences during the day.

In the history of civilization certain ideas and beliefs were due to certain drives in the important personages of the time. The history of religious beliefs is quoted to substantiate this point of view. A genius shows one similarity with the paranoid. He sticks tenaciously to a set of beliefs, which he has himself evolved, for many years. This is best illustrated in the cases of Darwin, Einstein, etc.

The process of recognition can be divided into three stages. In the first step, the individual experiences an undifferentiated mass of sensations which consist of sensory impressions, vague ideas without specific concentration on any object in the outside world. In the second stage, the individual begins to form vague,

general ideas of the presenting experience or object. In the third stage, clear, definite, conscious concepts are formed. The psychotic patient may stop at either one of these stages in his relation to the outside world. Either of these stages can become extremely modified and exaggerated in the patient. Back of the whole process lie the individual drives which compel him to get acquainted with his environment.

The concrete content of recognition consists of judgment, that is, evaluation of experience and formation of concepts. The tendency to generalize to the extreme is illustrated in the insane as expressed by their strange and grotesque ideas. Concept formation through generalization is observed strikingly in primitive man. Levy-Bruhl describes the extraordinary power of generalization in the case of a certain tribe of Mexican natives who state that a deer is also a cactus. Recognition involves thought processes. The same three stages are followed in thought processes, the only difference being that thought does not always lead to the formation of clear concepts. In paranoid patients the third stage of recognition may be expressed very suddenly. The whole problem may be solved instantaneously. Thought processes occasionally follow the same rule in psychotic patients.

Thought can be divided into reflex thought and intuitive thought. Reflex thought is the ordinary thought which is a subject of normal psychology. Intuitive thought gives immediate and ready solution of a problem. It does not involve any proof. It is thought without thought. Yet the results of intuitive thought are practically as good as thought which goes through the ordinary stages of procedure, because the intuitive thinking is so closely associated with the drives of the person himself.

There is also a form of thought which expresses itself through an immediate motor response. This is called thought through action. Thought through action results in instinctive recognition. It is really nothing else but action through intuition.

There are three common forms of thought which are found in most people. The first form of thought is found in those who grope around vaguely in their environment without any aim or goal and without determination of their relationship to the object. A person who is arrested at this stage of development is called the "lyric" person. In the second form of thought the drive is directed toward a definite object, known to the person himself, and yet the man still has no clear and definite concept of the object. The man who remains fixed in this stage is called the "metaphysical" person. This man is midway between the poet and the scientist. When a man is able to make clear definite concepts, one speaks of the exact type of thought in an "exact" person.

The monograph gives an excellent review of the subjects of feeling and recognition. The author takes up the whole subject from a broad point of view. His comparisons with the conscious and subconscious life of normal people are instructive and at times illuminating. The manner of presentation of the whole subject suffers somewhat on account of too much schematization and a tendency to overclassification, which according to the author himself is artificial and unnatural. One may regret the absence of histories in his cases. The author gives only short and concise information about his patients, tending to illustrate a certain condition which he is describing. Looking at psychiatry from a psychobiologic point of view, one feels that there is too much rigidity and artificiality in the author's attempt to analyze separately the various aspects of the subject with which he is dealing.

L'UNITÉ PSYCHIQUE ET LES TROUBLES MENTAUX. By MAURICE MIGNARD. Pp. 318. Paris: Félix Alcan, 1928.

This work, published posthumously, contains a curious mixture of keen observation and analysis with metaphysical leanings to which René Legendre, in a brief biography of the author, refers as a faith "of which Mignard had great need" owing to failing health. As the title indicates, the main thesis of the work is a

protest against the doctrine of mental dissociation and an effort to establish the essential unity of the consciousness or mind. Mignard quotes largely from Bergson, with whom, however, he is not in entire accord, and discusses in some detail the views of Bleuler and Freud. He objects to the use of such terms as the subconscious and the unconscious and maintains that the phenomena of mental disorder can all be explained by what he calls "subduction mentale." The essence of the mental unity is its power of self direction and control, which Mignard designates by the term "autoduction mentale"; this unity, or as one might call it the soul, works only through the soma as a whole, and any disorder that appears in the body, whether due to disease or to some other anomaly, may interfere with the self direction of the soul and thus bring about a diminished control which is indicated by the word subduction.

In support of his contention, the author analyzes many different symptoms, including obsessions, hallucinations, delusions, affective oscillations, epileptic manifestations and schizophrenic features. He objects to the conception of mind as a composite of memories and maintains that even in the organic dementias there is no true loss of mind; all that happens is that through the damage to brain pathways autoduction is gravely reduced. Nevertheless, with subsidence of the brain disease, as in paresis, for example, the mind returns and the memories are still there.

To illustrate the position taken, Mignard compares his concepts with those of modern physics. He points out that the physicist concerns himself only with relativity which he can measure and ignores the essence of the matter in which the relations are developed. In the same manner, the psychiatrist has concerned himself only with the relations of the personality with its surroundings and has ignored the essence or the unity of the mind or soul. It is interesting that he objects to the freudian concept of the wish or desire as a unit of mental activity; yet, when he comes to analyze psychasthenic obsessions one finds him using the mechanisms of "intense désir" and "la satisfaction."

There is much of interest in the book, and the views lead to strong emphasis on the need for close cooperation between psychiatry and medicine in general, for one must look for the causes of the "subduction mentale" in disorders of the physiologic mechanisms of the body.

DIE LABYRINTHREFLEXE AUF DIE AUGENMUSKELN NACH EINSEITIGER LABYRINTHEXTIRPATION. By R. LORENTE DE NÓ, M.D. Price, 15 marks. Pp. 205. Berlin: Urban & Schwarzenberg, 1928.

This important monograph does not lend itself well to abbreviation. It consists of an exhaustive critical review of the literature and a description of numerous personal experiments, which are critically analyzed and confirmed by careful anatomic study. One is impressed by the author's realization of the incompleteness of our knowledge of the central connections from the labyrinth. The investigation, at first concerned with graphic representation of nystagmus following extirpation experiments, is led into a highly technic analysis of a mathematical nature.

The author has observed, following longitudinal section of the medulla and pons and transverse section of the pons, that decerebrate rigidity may be present and righting reflexes absent with an intact red nucleus, which naturally leads to the conclusion that, contrary to Rademacher, the red nucleus is not the center for the organization of righting reflexes and for the normal distribution of tone in the extremities. He finds it unnecessary to allocate to any particular part of the labyrinth the function of stimulation of a particular muscle, and thinks that stimulation of the same area may at one time produce reaction in one group, and at another time, under different conditions, in another group of muscles.

The rapid phase of labyrinthine-induced nystagmus is closely connected with the integrity of the substantia reticularis of the pons. At the present time, one is unable to describe the labyrinthine connections or designate the mechanism responsible for the disappearance of nystagmus. The rapid and slow components

of nystagmus need not originate from different end places in the labyrinth, but it may be that from a single stimulation of the crista there is released a diphasic reflex, like the scratch reflex.

Although some of this experimental material is not of general interest to the clinical neurologist, a large part of the monograph is replete with interesting and important observations. To the experimental neurologist it is an important contribution.

EXPERIMENTELLE NEUROLOGIE. By E. A. SPIEGEL. Price, 24 marks. Pp. 281. Berlin: S. Karger, 1928.

The author proposes to present in an accessible and comprehensive form a textbook dealing with the physiologic aspects of the nervous system. This volume is the first part of this treatise. Herein the author describes the methods of investigation which are at one's disposal, the general characteristics of nerve impulses, the reflex activities of the central nervous system, the segmentation of the spinal cord and roots and the vegetative nervous system. In the promised volume there will appear a consideration of static and kinetic innervation, the course of the centripetal nerve impulse, the physiology of consciousness, the circulation of the blood and spinal fluid and a complete bibliography.

In the first chapter is contained an excellent review of methods of experimental research, both stimulation and destruction. In the second chapter, electrophysiology of nerves is considered, the all or none principle, the refractory phase, relative indefatigability and chemistry of nerves. Then the theories of nerve impulse are discussed and the results of nerve section considered. Then follows a description of the function of nerve centers. The third chapter deals with the reflex activities of the central nervous system, and encompasses in a short space an able and comprehensive digest of present knowledge of the subject. Chapter 4 deals with the segmental functions of the spinal cord and roots; chapter 5 deals with the vegetative nervous system; the author here gives a lucid and critical review of the subject. Throughout the volume he is free from prejudice, and presents controversial material from all sides. When finished, this work will represent an outstanding contribution to neurologic literature. It is hoped that a translation into English will be forthcoming.

ENDOCRINE DISEASES. By PROF. HANS CURSCHMANN. Volume 1. Price, 8.50 marks. Pp. 151, with forty-eight illustrations. Dresden: Steinkopff, 1927.

This little volume by Curschmann is a compact clinical survey of the disorders of the endocrine glands. It is one of a series of volumes on the practice of medicine. The book deals concisely and yet not too briefly with the various diseases of the endocrine glands. Each disease is discussed from the standpoint of occurrence, etiology, course and symptomatology, diagnosis and treatment. A particularly good feature of the volume is the fact that, although the account aims to be concise, room is found for reference to authorities. For a small volume it is comprehensive and not too didactic. There is an interesting little discussion of the incomplete forms of hyperthyroidism, with an attempt to classify these obscure disorders. There is rather a full discussion of tetany with the assertion that the nervous system in typical cases does not show any organic changes, particularly no paresis, atrophy or changes in the cranial nerves or reflexes. The discussion on disorders of the pituitary gland is fairly complete, though mention is not made of the work of Cushing. Curschmann states that nervous symptoms in adiposis dolorosa are frequent, and that the depressive neurotic state in this condition is so frequent that he considers it pathognomonic. There is a brief but adequate discussion of intersexuality and homosexuality.

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